A practical way to implement ISO 15288 V&V processes:
The V&V Studio

the REUSE company

2nd & 4th June, 2020

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TRC WEBINARS 2020

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01 The company was created in **1999**

As a spin-off of a University in Europe

02 **System + Software Engineers**

Smart combination between Company staff and R&D from Academia

03 **Headquarters:**
Madrid (Spain)

International offices:
Stockholm (Sweden)
Tokyo (Japan) Delegation

2021:
USA
Chicago/Detroit/Miami

04 To promote a **reusable**, **scalable** and global solution to a **smart** and **interoperable** Systems Engineering environment, by offering a **semantic knowledge centric** approach.

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Research and Innovation in our DNA

Spin-off of Carlos III University of Madrid
TRC's headquarter is in the Legatec Technology Park of the University
≈10% of revenues are devoted to R&D
TRC is actively involved in several large EU research projects

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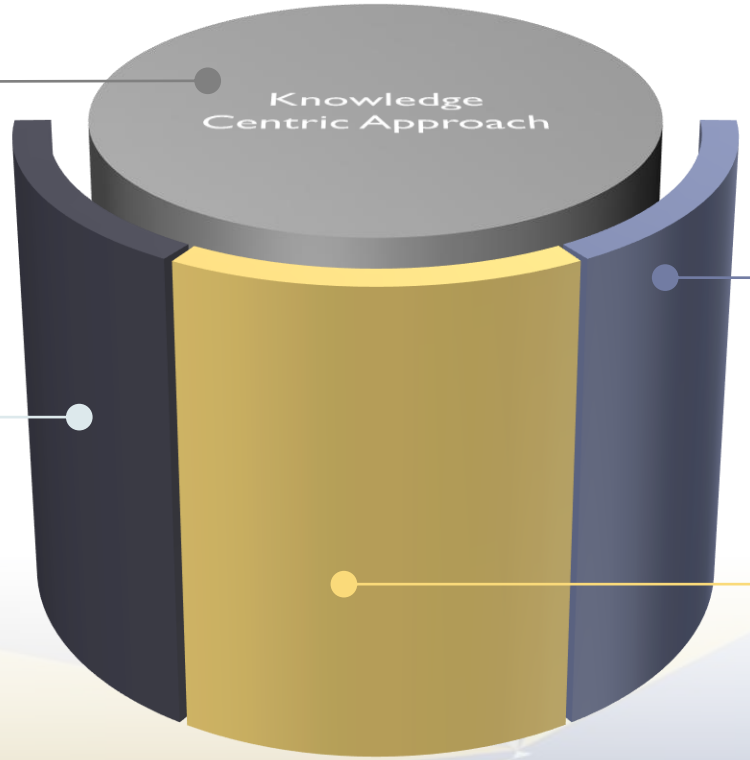
T (he) R (euse) C (ompany)

Knowledge Centric Systems Engineering (KCSE)

Global Repositories –
Archiving –
Configuration Management –

TRACEABILITY

Links and Interoperability –
Transformations –
Change management –



QUALITY (ies)

- Quality Management
- Verification & Validation management
- Risks Management
- Smart Authoring

REUSABILITY

- Interoperability
- Retrieval & Archiving
- Adaptability to Existing Toolsets

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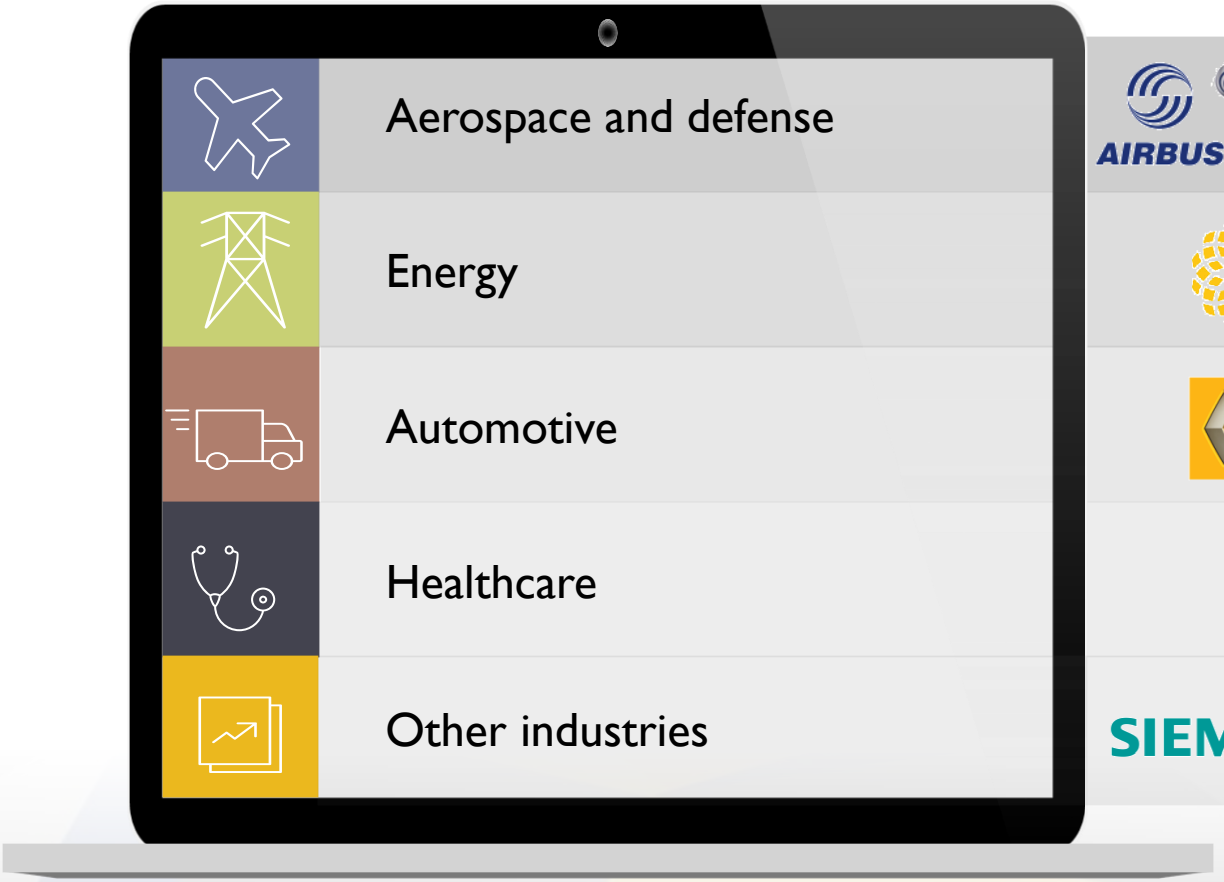

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THINK SURGICAL · Health Net

SIEMENS · acciona Agua · orange · rtve · ELRA European Land Registry Association · tirant lo blanch

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- SE Professor at Universidad Carlos III de Madrid (Spain)
- CTO at The REUSE Company
- Former President of AEIS (INCOSE Spain)
  - Member of INCOSE and AEIS
  - Former INCOSE Ontology Working Group Chair
  - Member of INCOSE Requirements Engineering WG
  - Contributor (review) to INCOSE Guide for Writing Requirements
  - Certified Systems Engineering Professional (CSEP)
  - Expert Systems Engineering Professional (ESEP)

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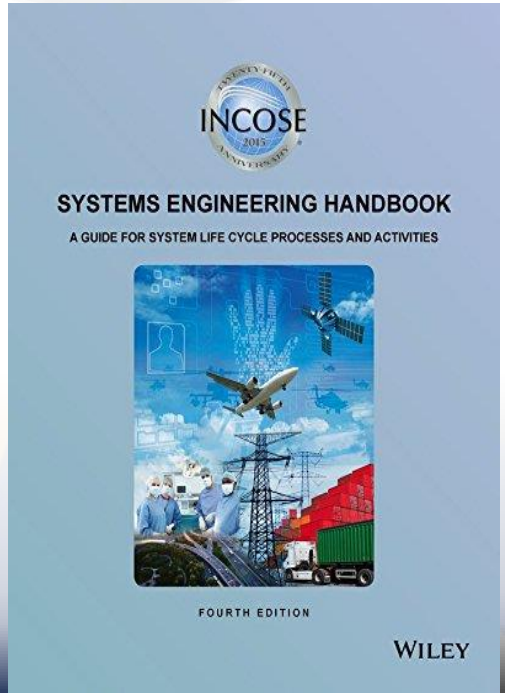
V&V (Verification and Validation) Processes



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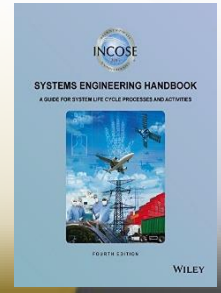
Verification Process (ISO/IEC/IEEE 15288)

- *"The purpose of the Verification process is to provide objective evidence that a system or system element fulfils its specified requirements and characteristics."* (SEHb p.83)



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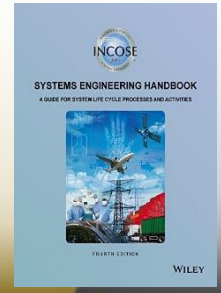
Validation Process (ISO/IEC/IEEE 15288)

- *"The purpose of the Verification process is to provide objective evidence that a system or system element fulfils its specified requirements and characteristics."* (SEHb p.83)

- *"The purpose of the validation process is to provide objective evidence that the system, when in use, fulfills its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment".* (SEHb p.89)



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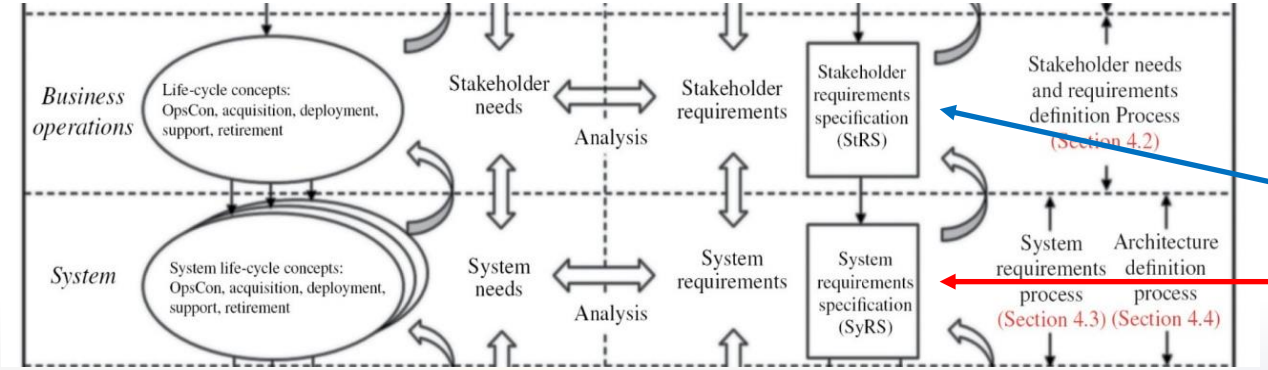
Verification and Validation are not the same

- *"The purpose of the Verification process is to provide objective evidence that a system or system element fulfils its specified requirements and characteristics."* (SEHb p.83)

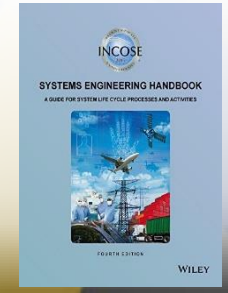
- *"The purpose of the validation process is to provide objective evidence that the system, when in use, fulfills its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment".* (SEHb p.89)



Source: Mike Ryan - > SE Handbook V4

Validation

Verification



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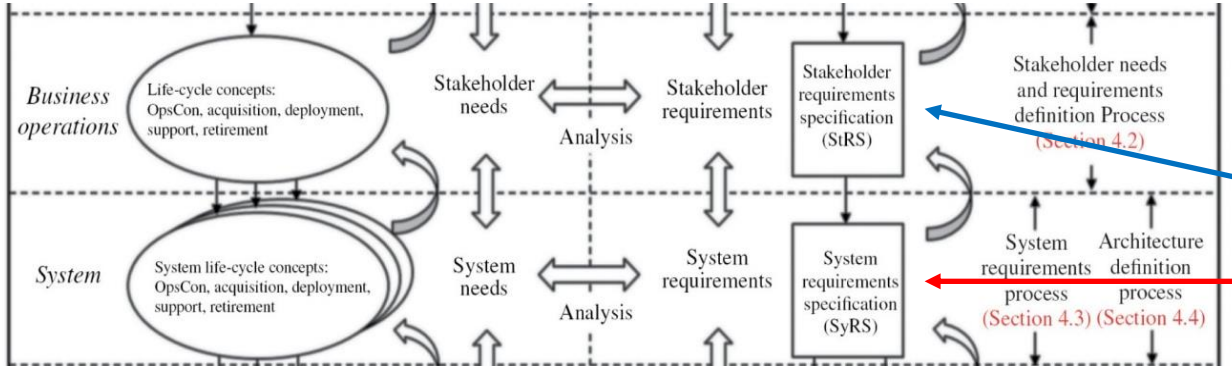
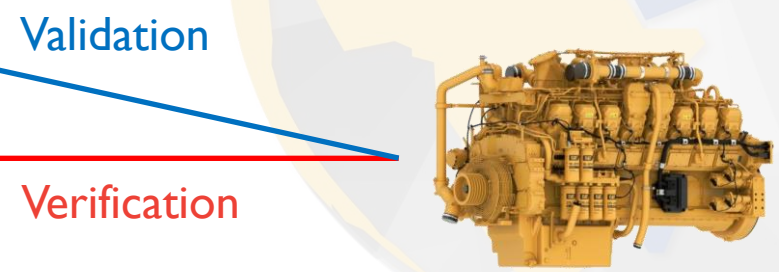
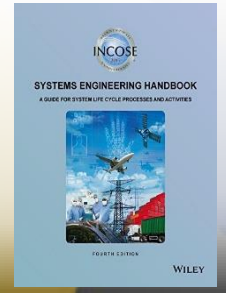
Verification and Validation are not the same



Source: Mike Ryan - > SE Handbook V4



- Verification and Validation are not the same (*"build the thing right"* vs *"build the right thing"*):
  - Context is (very) different
  - Scope is different
  - … even if both use the same methods and tools
  - Therefore, for the purpose of this presentation, We´ll center our message in the Verification Process
    - Assuming that everything can be applied to both V&V



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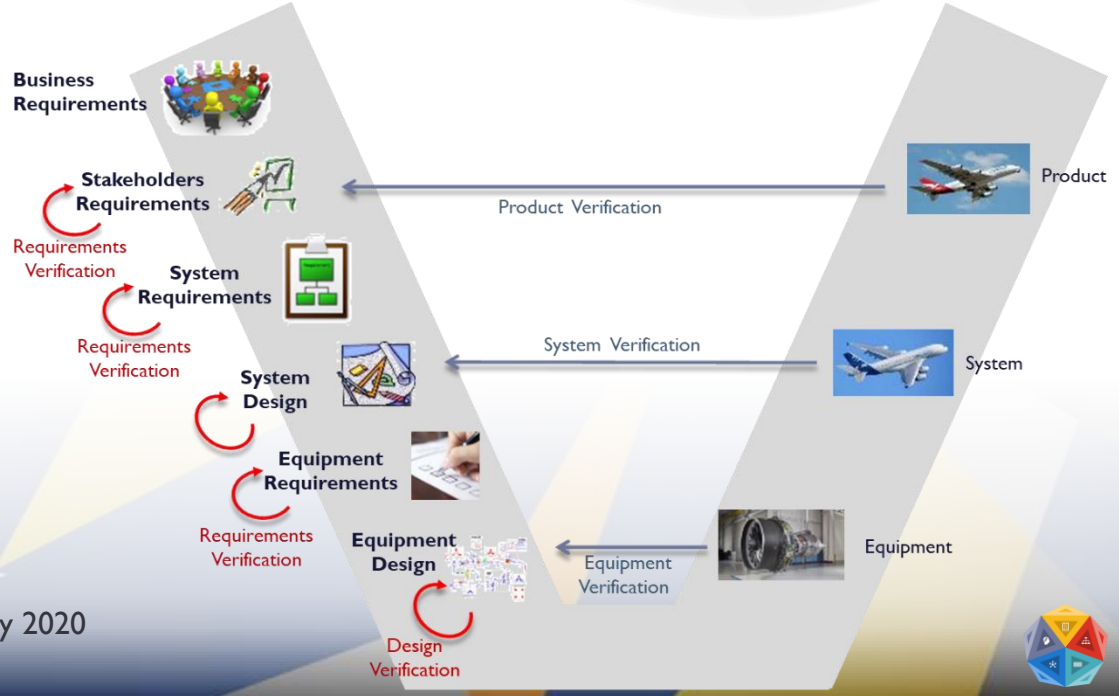
What to Verify / Validate

- The INCOSE Systems Engineering handbook (V4) states the focus in a more precise way:
  - *"The verification process can be applied to any engineering element that has contributed to the definition and realization of the system itself (e.g., verification of a system requirement, a function, an input/output flow, a system element, an interface, a design property, a verification procedure)".* (SEHb p.83)
- This statement widens the Verification process goal to what it really stands for:
  - To provide objective evidence that whatever engineering item (requirement, requirements set, model element, model(s), function, etc.), system element or the SOI itself has been "built right".
- The result is that the Verification process must be applied universally and transversely both R2L of the V-Model (the most known) as well as L2L (or even R2R)



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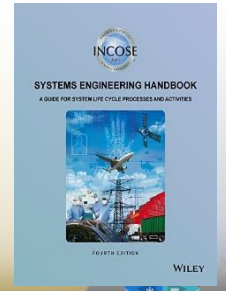
What to verify controversy

Verify the Requirements against the SOI / SE?

Verify the SOI / SE against the Requirements?

Items	Explanation for Verification
Document	To verify a document is to check the application of drafting rules.
Stakeholder Requirement and System Requirement	To verify a stakeholder requirement or a system requirement is to check the application of syntactic and grammatical rules, characteristics defined in the stakeholder requirements definition process, and the system requirements definition process such as necessity, implementation free, unambiguous, consistent, complete, singular, feasible, traceable, and verifiable.
Design	To verify the design of a system is to check its logical and physical architecture elements against the characteristics of the outcomes of the design processes.
System	To verify a system (product, service, or enterprise) is to check its realized characteristics or properties against its expected design characteristics.
Aggregate	To verify an aggregate for integration is to check every interface and interaction between implemented elements.
Verification Procedure	To verify a verification procedure is to check the application of a predefined template and drafting rules.

https://www.sebokwiki.org/wiki/System_Verification



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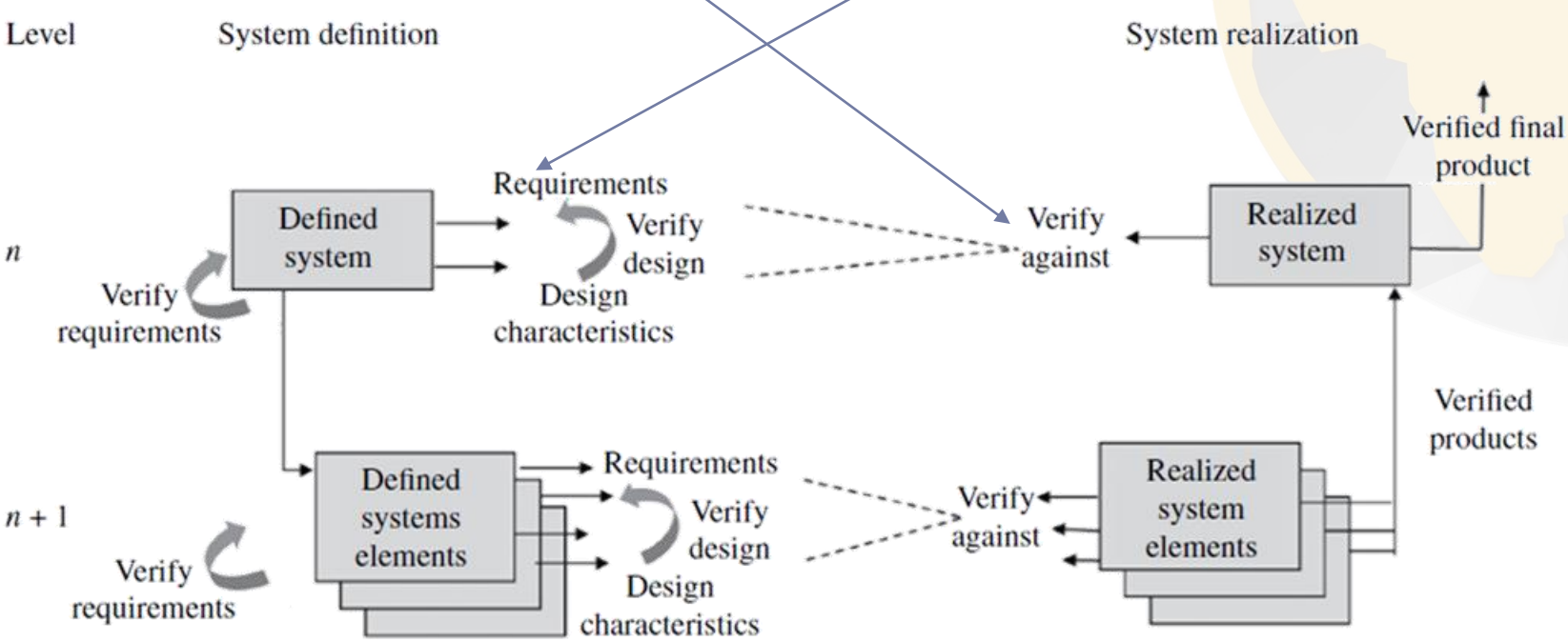
What to verify controversy

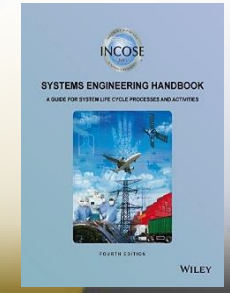
Verify the verifiable item against Source Items

And you decide your way ☺



Why the debate?
For Tool Vendor to decide meta-model

Source: Systems Engineering Handbook V4 - Fig 4.15 p.87



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What to verify controversy

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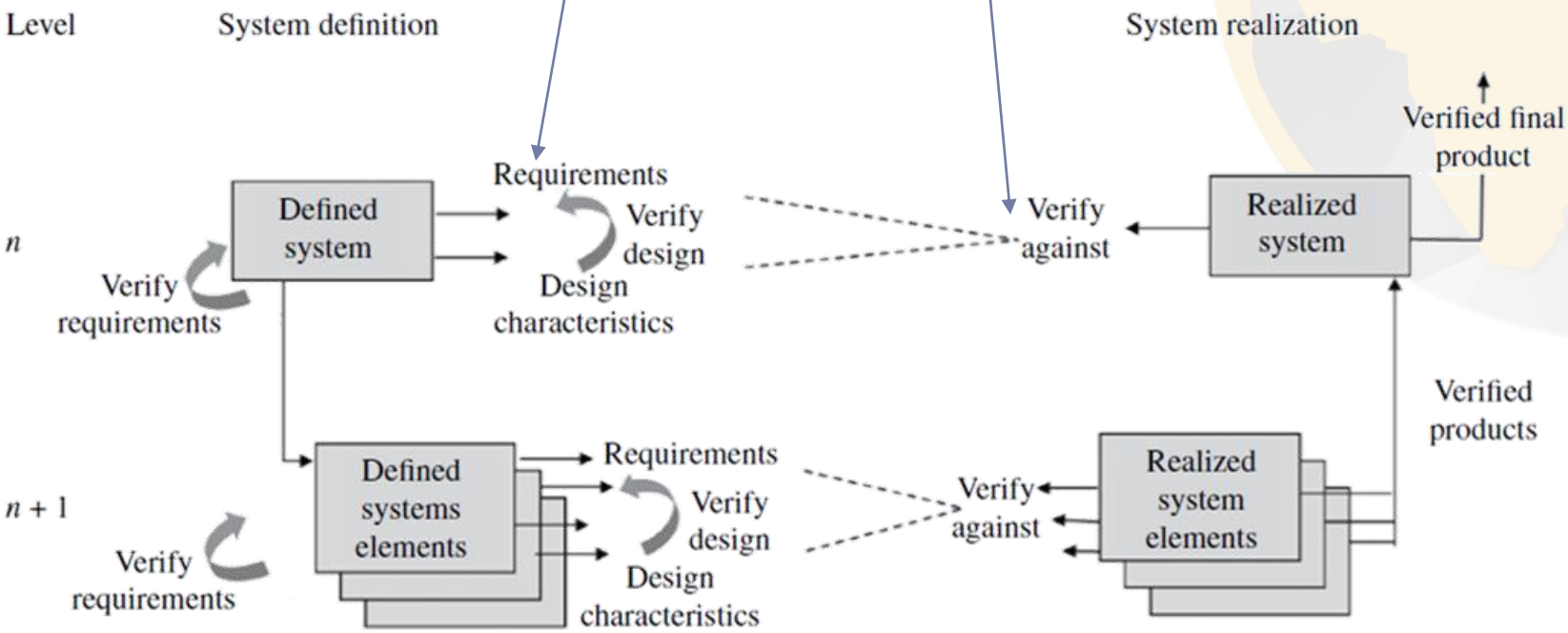

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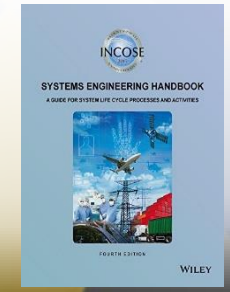

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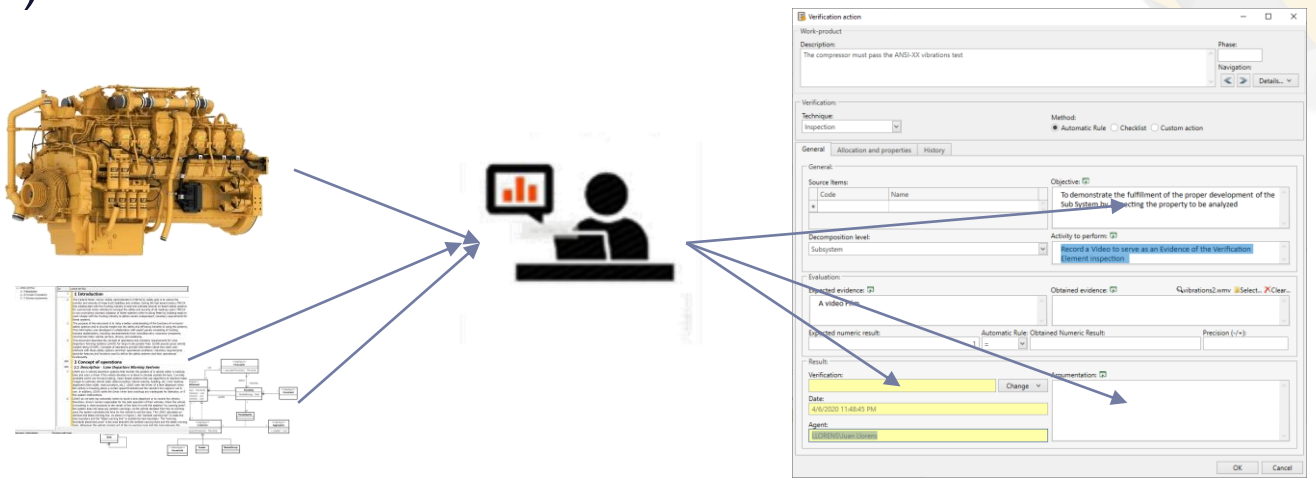
- The Verification Process implementation evolves around the notion of VERIFICATION ACTION.
- A Verification Action defines a structured representation (digital) of what is considered necessary to assure that the verified element fulfils its specified requirements and characteristics.
- The Verification Action (VA) is intended to serve as a mean to provide objective evidence that a work-product has (or has not) been verified.



- The process of defining, configuring, scheduling, filling, analyzing, managing and reporting VAs is called the Verification Process

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Verification Action: Attributes 1/2

Attribute	Description	Attribute	Description
Verifiable Item	The work-product that is being verified It responds to the question: What product is verified?	*Activity to Perform*	Description of the work to be done within the verification action.
Source Items:	The engineering items that serve as source information It responds to the question: which item(s) should be taken as reference to verify the verifiable item?	*Expected Evidences (Expected Results)*	The expected results of the verification. Indicates the objective evidence that should be compared with the obtained results for verification confirmation (or rejection, if not enough).
The verification technique(s) to be used	Several options are supported in the literature: Inspection, analysis, demonstration, test, analogy or similarity, simulation, sampling, other	*Expected Numeric Result*	Represents the expected numeric results as a quantitative value. It can be used for automating purposes
Decomposition Level of the System	SOI, sub-system (intermediate system element), component (leaf level system element).	*Obtained Evidences (Obtained Results)*	The results of the verification. Indicates the obtained objective evidences that serve for verification confirmation against the expected evidences (or rejection if not enough).
Phase	Phase in which the verification will be performed. This attribute allows to define dependencies between the verification actions so that they can be performed in a defined order	*Obtained Numeric Result*	The actual result of the verification but using a quantitative value. It can be used for automating purposes, like automatically comparing this value with the expected result and providing a candidate verification value.
Objective	What is to be accomplished by the verification process. In the case of engineering items, this attribute represents the reference used to define the expected result	*Performing Organization or Person*	Organization responsible for leading the verification activity.

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Verification Action: Attributes 2/2

Attribute	Description	Attribute	Description
Starting Date	Date when the verification activity started.	*Funds Resource*	Numeric value that manages the real money devoted to the verification.
Ending Date	Date when the verification activity ended.	*Facility Resource*	Facility, laboratory or SW tool used to perform the verification activity.
Estimated Time Resource (Days)	Numeric value for the expected time to be devoted to the verification.	*Verified*	Represents information about the state of the verification action. The most usual states are Yes and No values: Yes if the work-product has been verified (true) and No if the work-product has not been verified (false). However, as you'll see later, V&V Studio supports several different states (See section 6.3 How Is the Verification Execution in V&V Studio).
Estimated Labor Resource (Hours/Person)	Numeric value for the expected hours/person to be devoted to the verification.	*Verified Date*	Date when the verification activity ended.
Estimated Funds Resource	Numeric value for the expected money to be devoted to the verification.	*Verified Agent*	Person that "certifies" the verification.
Time Resource (Days)	Numeric value that manages the real time devoted to the verification.	*Automatic Verification Rule*	Rule to be applied for comparing the Expected Numeric Result and the Obtained Numeric Result, in order to automatically suggest a value for the "Verified" attribute.
Labor Resource (Hours/Person)	Numeric value that manages the real hours/person devoted to the verification.	*Other attributes*	Customized attributes from the user. They can vary for every different verifiable item type.

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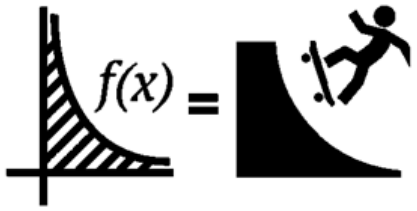
Inspection

Analysis

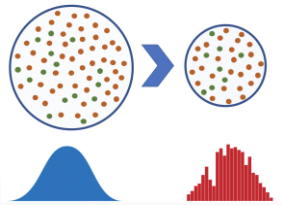


Demonstration

Test

Analogy or Similarity

Sampling



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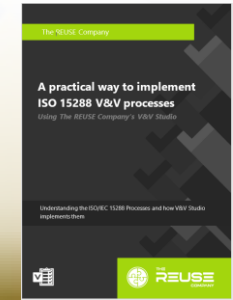
Inspection

- Based on visual or dimensional examination of an element
- Relies on the human senses
  - or uses simple methods of measurement and handling.
- Generally nondestructive
  - and typically includes the use of sight, hearing, smell, touch, and taste
- Simple physical manipulation / mechanical and electrical gauging / and measurement.
- No stimuli (tests) are necessary



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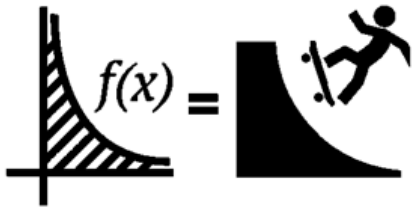
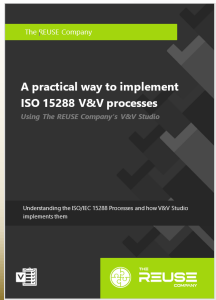


Analysis

- Based on analytical evidence
  - obtained without any intervention on the verifiable element.
- To show theoretical compliance => Mathematical or probabilistic calculation, logical reasoning (including the theory of predicates), modelling and/or simulation under defined conditions.
- Mainly used where testing to realistic conditions cannot be achieved or is not cost-effective.



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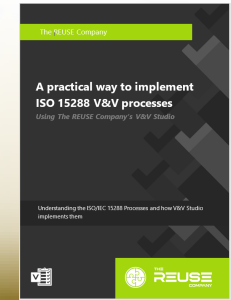
Demonstration Verification technique

Demonstration

- Used to show correct operation of the submitted element against operational and observable characteristics without using physical measurements
  - (or minimal instrumentation or test equipment).
- Generally uses a set of actions, selected to show that the element response to stimuli is suitable
  - or to show that operators can perform their assigned tasks when using the element.
- Observations are made and compared with predetermined/expected responses



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Test

- Performed onto the submitted element by which functional, measurable characteristics, operability, supportability or performance capability is quantitatively verified when subjected to controlled conditions that are real or simulated.
- Often uses special test equipment or instrumentation to obtain accurate quantitative data to be analyzed.

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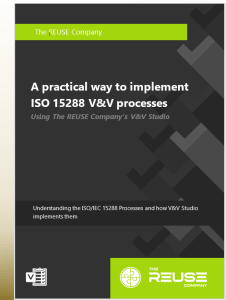
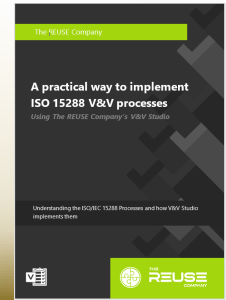


Analogy / Similarity Verification technique

Analogy or Similarity

- Based on evidence of similar elements to the submitted element or on experience feedback.
  - It is absolutely necessary to show by prediction that
    - the context is invariant
    - the outcomes are transposable.
    - (e.g., models, investigations, experience feedback).
- Can only be used if the submitted element is similar in design, manufacture, and use.
- Equivalent or more stringent verification actions were used for the similar element.
- The intended operational environment is identical to or less rigorous than the one applied to the similar element.
- A kind of V&V Reuse.



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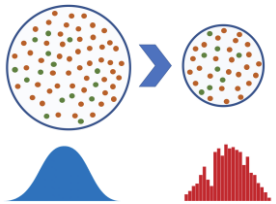
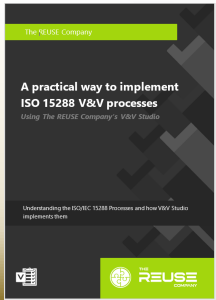
Sampling Verification technique



Sampling

- Based on verification of characteristics using samples.
- The number, tolerance, and other characteristics must be specified and in agreement with the experience feedback.



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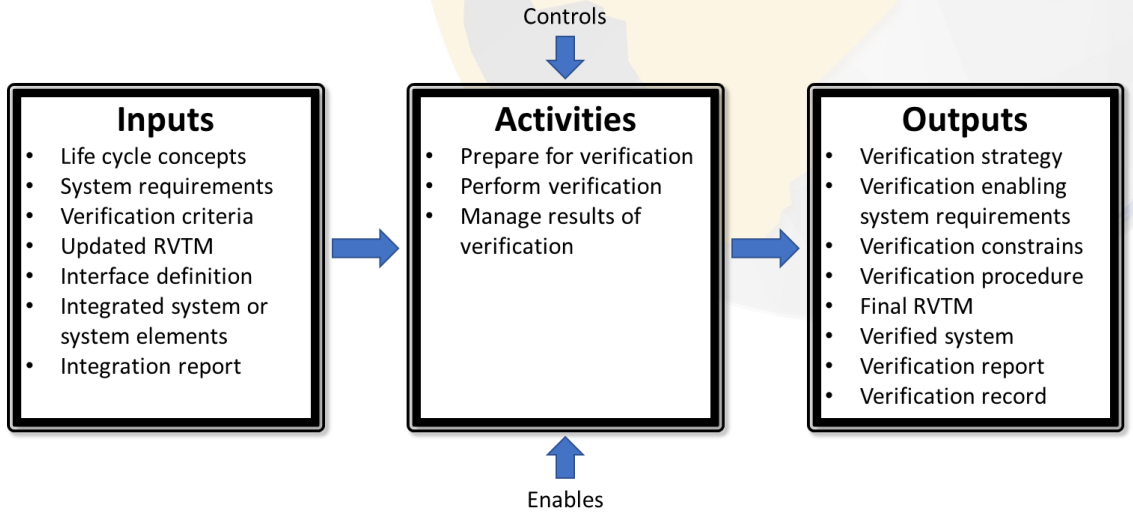
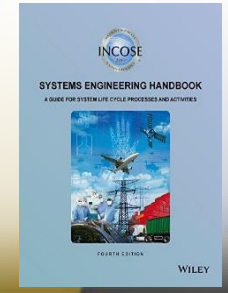
- A process is best defined using inputs, outputs and activities to be developed in it.

- Based on the ISO 15288 Standard, a good implementation of the Verification Process must support the realization of the following activities:
  1. Prepare for verification
  2. Perform verification
  3. Manage results of verification

- Next Section: A detailed description on how to implement the activities using the V&V Studio





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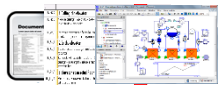
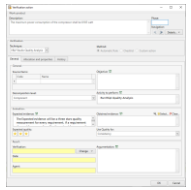
Verification Process in a Nutshell

Prepare for Verification

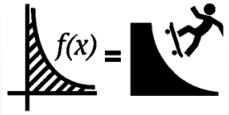


Select the Items to be Verified

Prepare Strategy and Resources of all types, Identify constraints, Enabling Systems, etc.

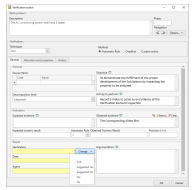


Define a Verification Action for each Verifiable Item



Define a Verification Technique for each Verifiable Item

Perform Verification



Execute the Verification Action for each Verifiable Item
(fill the corresponding information)

Engineer applies the OK / KO decision process based on the standard guidelines.

Manage Results of Verification

Manage and record discovered anomalies

Track the Verification Process
and manage Configuration

Build and maintain the RTVM

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	Verification	Validation
Process Definition	*The purpose of the verification process is to provide objective evidence that a system or system element fulfils its specified requirements and characteristics.*	*The purpose of the validation process is to provide objective evidence that the system, when in use, fulfills its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment.*
Scope	*The verification process can be applied to any engineering element that has contributed to the definition and realization of the system itself (e.g., verification of a system requirement, a function, an input/output flow, a system element, an interface, a design property, a verification procedure).*	*The validation process is applied to a system of interest, or any system or system element that composes it, at the appropriate points in the life cycle stages to provide confidence that the right system (or system element) has been built.* *The validation process can be applied to any system element or engineering item of the system or its definition that has been defined or realized.*
Activities	• *Prepare for verification* • *Perform verification* • *Manage results of verification*	• *Prepare for validation* • *Perform validation* • *Manage results of validation*
Conceptual Tool	*A verification action describes what must be verified (…), on which item (…), the expected result (…), the verification technique to apply (…), and on which level of decomposition of the system.*	*A validation action describes what must be validated, on which item, the expected result, the validation technique to apply, and on which level of the system hierarchy.*
How To	*The engineer performs verification by creating and managing verification actions as means to produce evidences.*	*The engineer performs validation by creating and managing validation actions as means to produce evidences.*

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Automating the Verification Process

(Connecting the notions of Quality and Verification)

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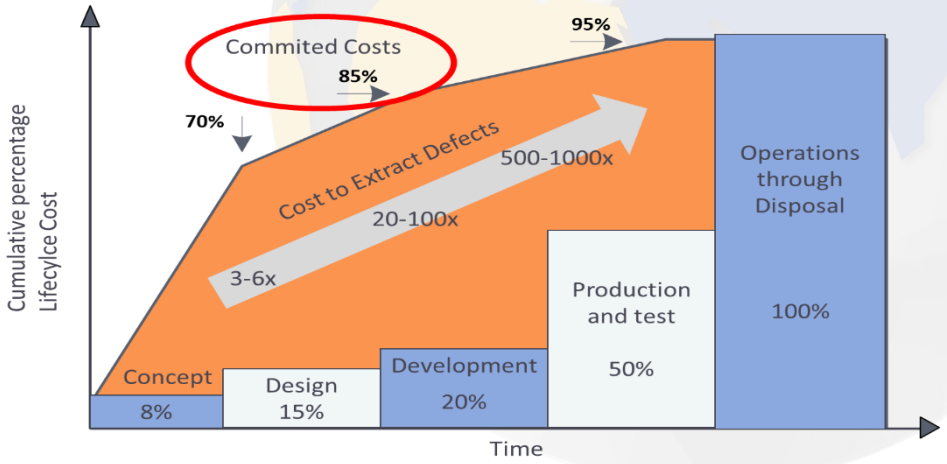
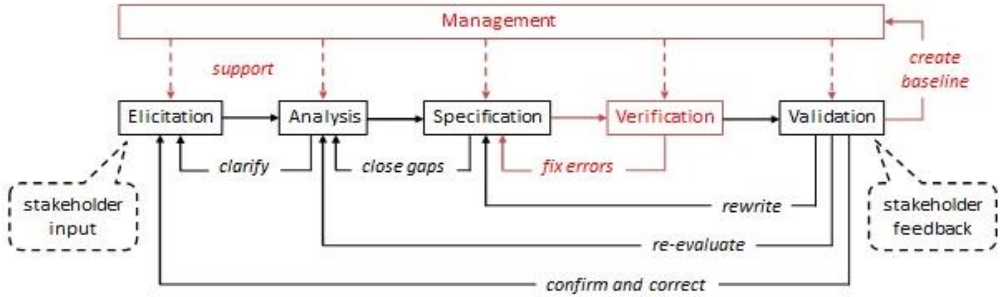
- The universalization of the Verification process can be found in the notion of quality
  - the less defects of any type produced during all the different life-cycle stages …
  - the better it will be to reduce cost, calendar time and quality… and V&V

- Combine Verification with Quality control + assurance is the kernel of this approach
  - One example of this combination is to apply the verification process to requirements:, requirements must be validated, and (now recently) verified





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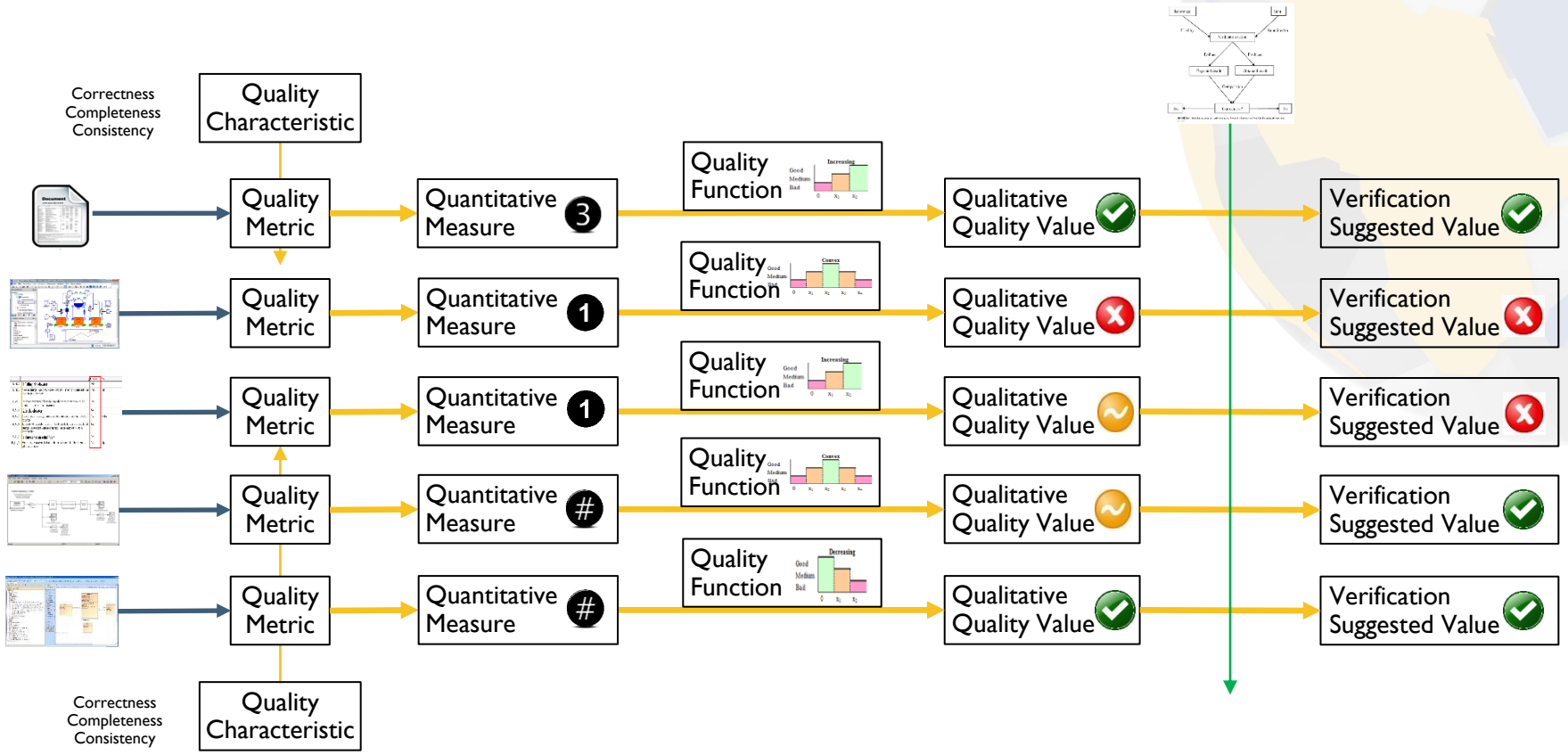
Obtained Result as Quality value



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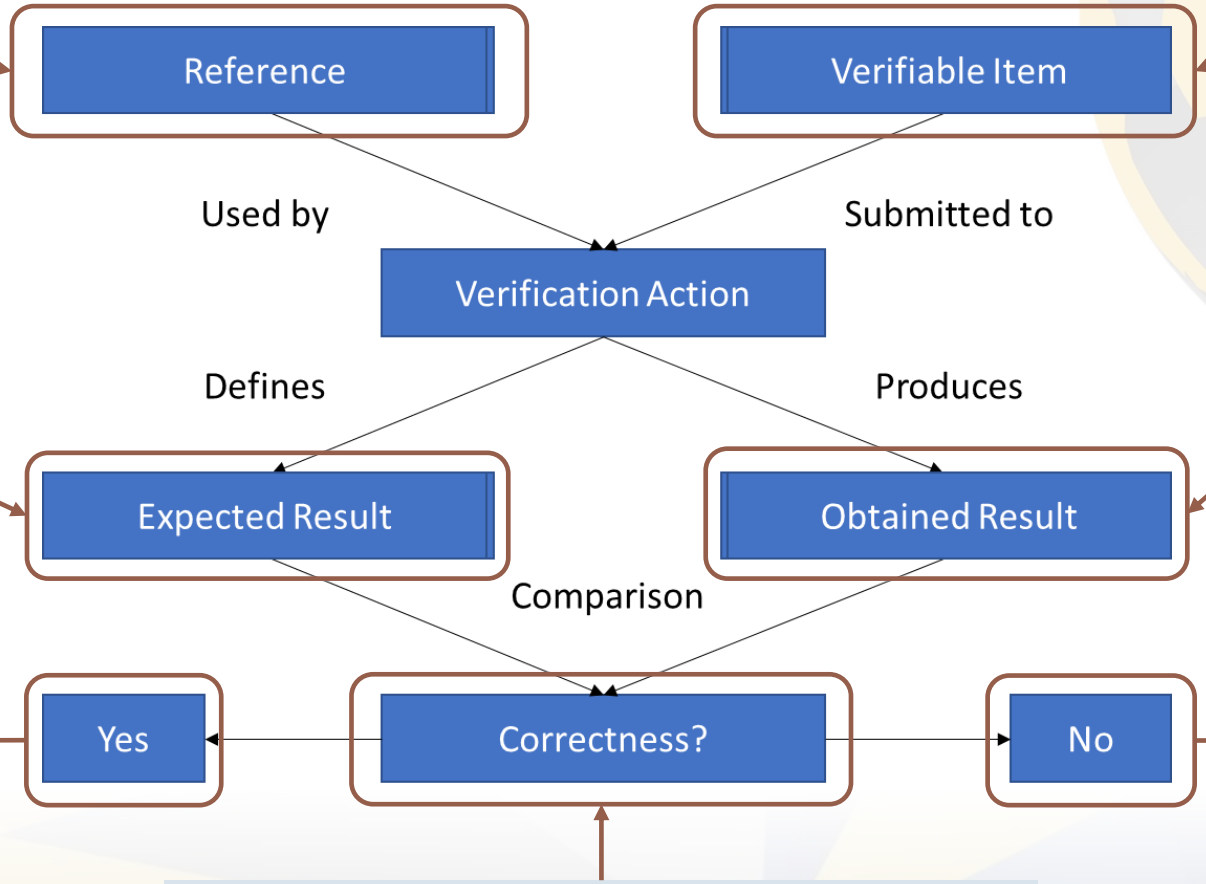
How to automate the Verification Process

Predefine the Reference Information in a VA

Connect to the Verifiable information supporting Tool (TeamCenter, Enovia, DOORS, etc.) and assign a VA to each one of them



Predefine what result must be expected

Automate (if possible) the process of calculating the Verification Result:
if analysis => get analysis results
If test => get test results
If check list => get checklist results

Assign Suggested YES (by the Computer)

Assign Suggested NO (by the Computer)

Engineer decides Final value

Define a Validation Function to map gathered results (quantitative values) with qualitative verification result

Engineer decides Final value

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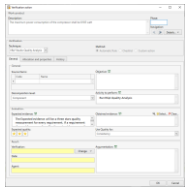
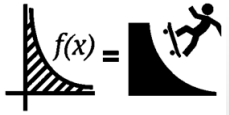
Prepare for Verification

Select the Items to be Verified

Prepare Strategy and Resources of all types, Identify constraints, Enabling Systems, etc.

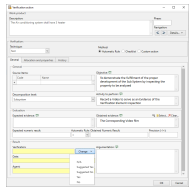


Define a Verification Action for each Verifiable Item



Define a Verification Technique for each Verifiable Item

Perform Verification



Execute the Verification Action for each Verifiable Item. If possible, the computer gathers the Information automatically

Computer applies the OK / KO decision process based on the standard guidelines.

Manage Results of Verification

Manage and record discovered anomalies and evidences

Track the Verification Process and manage Configuration

Build and maintain the RTVM

Provide proper reports

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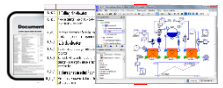
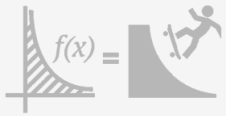
Prepare for Verification



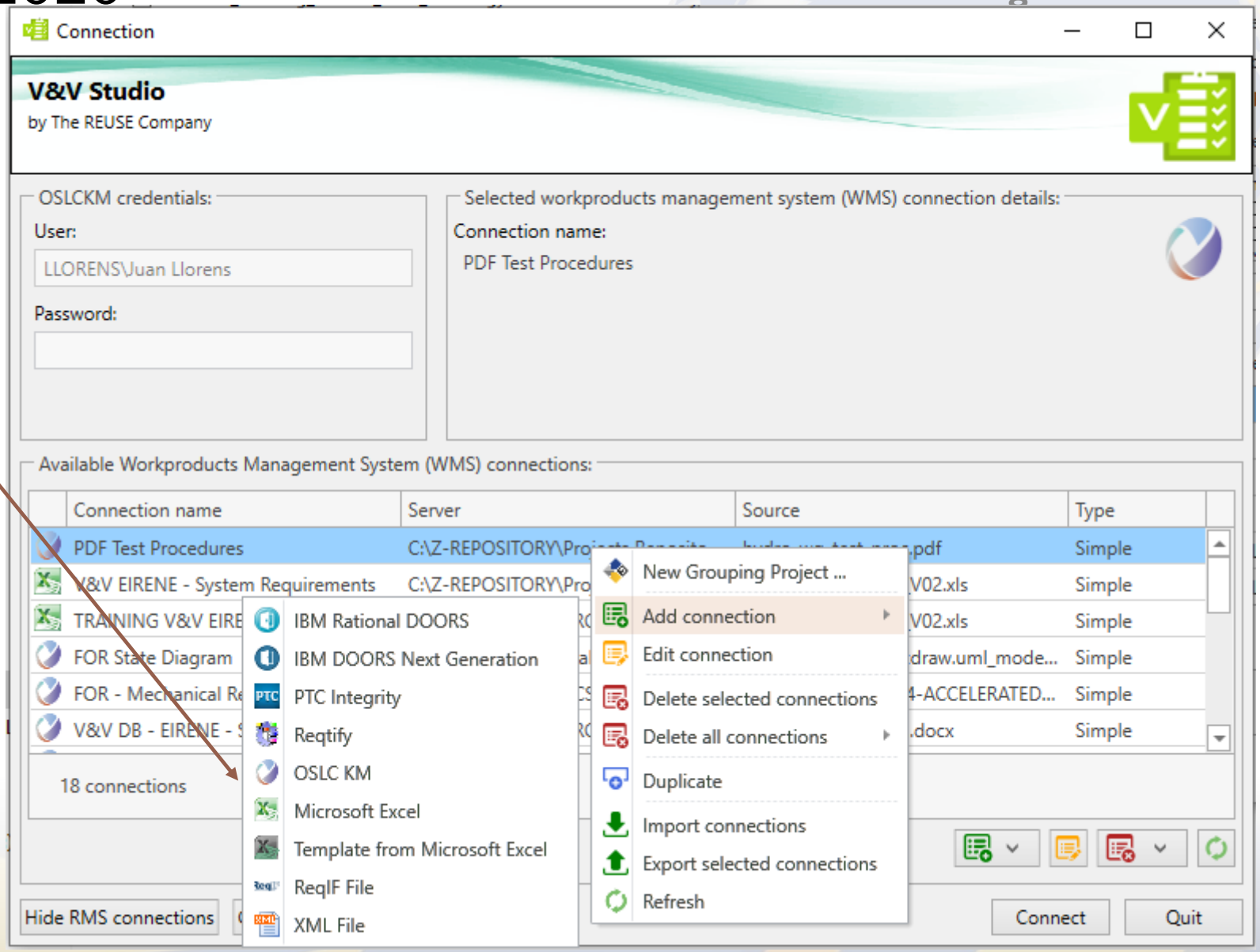
Select the Items to be Verified

Prepare Strategy and Resources of all types, Identify constraints, Enabling Systems, etc.

Define a Verification Action for each Verifiable Item



Define a Verification Technique for each Verifiable Item



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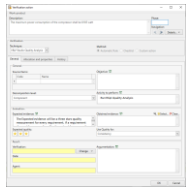
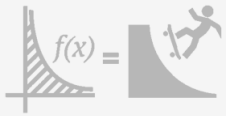
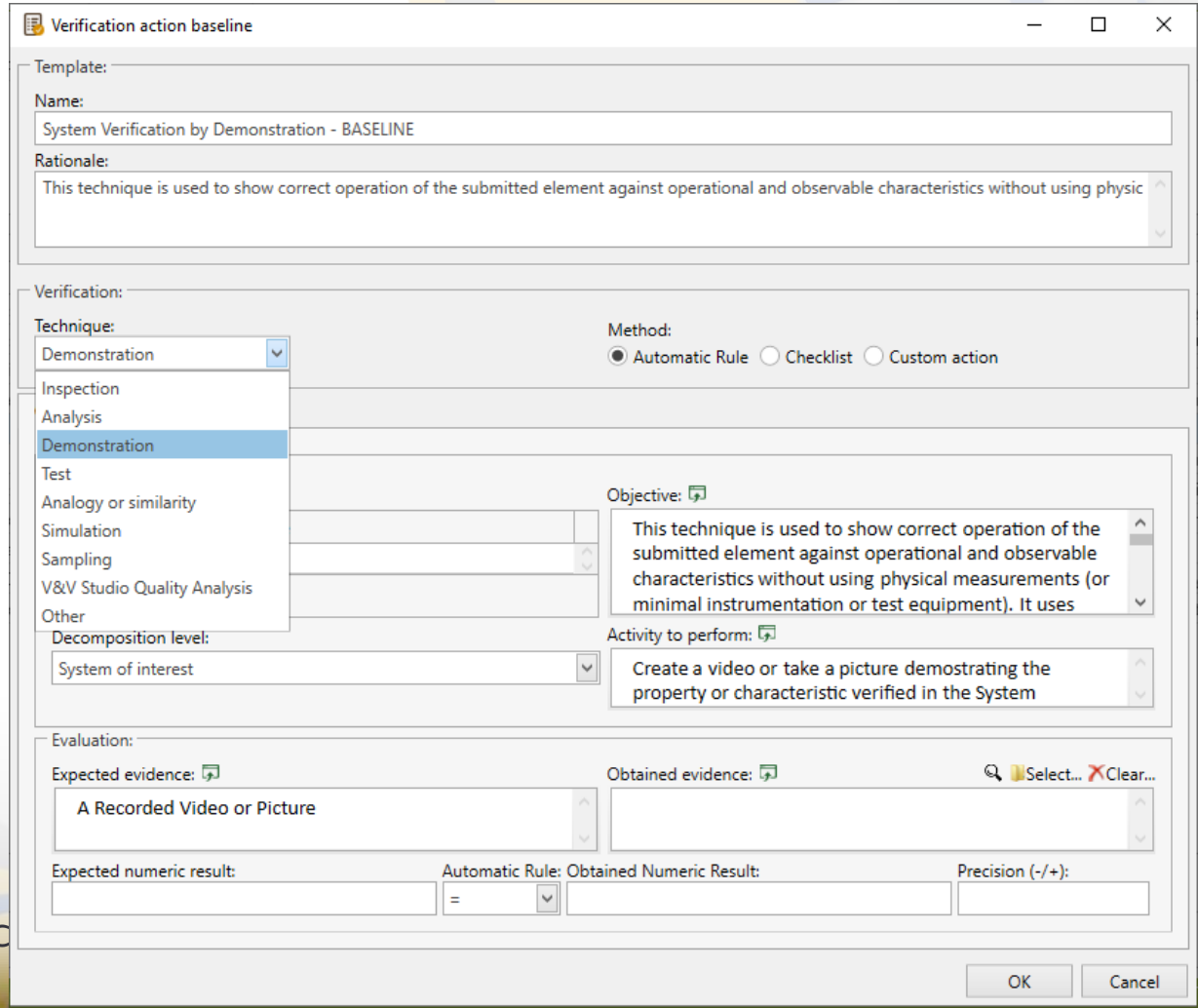


Define a Verification Action for each Verifiable Item



Define a Verification Technique for each Verifiable Item

By selecting a predefined VA template. i.e:
- Template for performing Inspection
- Template for producing a Check list
- Template for Simulation Analysis



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Prepare for Verification

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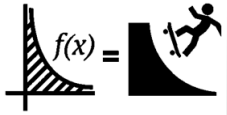
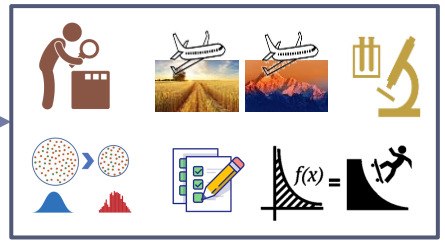


Define a Verification Technique for each Verifiable Item



Select a one Verification Technique or define your own one

Define If the obtained results will be gathered manually or automatically

- manually: (A human engineer fills data in the VA manually

Defining customizable Check-lists

Defining values to be expected

- automatically (a **Calculation Function** gets the obtained data into the VA)

Connecting to other tools

Calculating the Quality of Verifiable Item using RQA Tool

Defining your own Calculation Function

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Prepare for Verification

Select the Items to be Verified

Prepare Strategy and Resources of all types, Identify constraints, Enabling Systems, etc.

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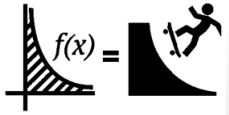

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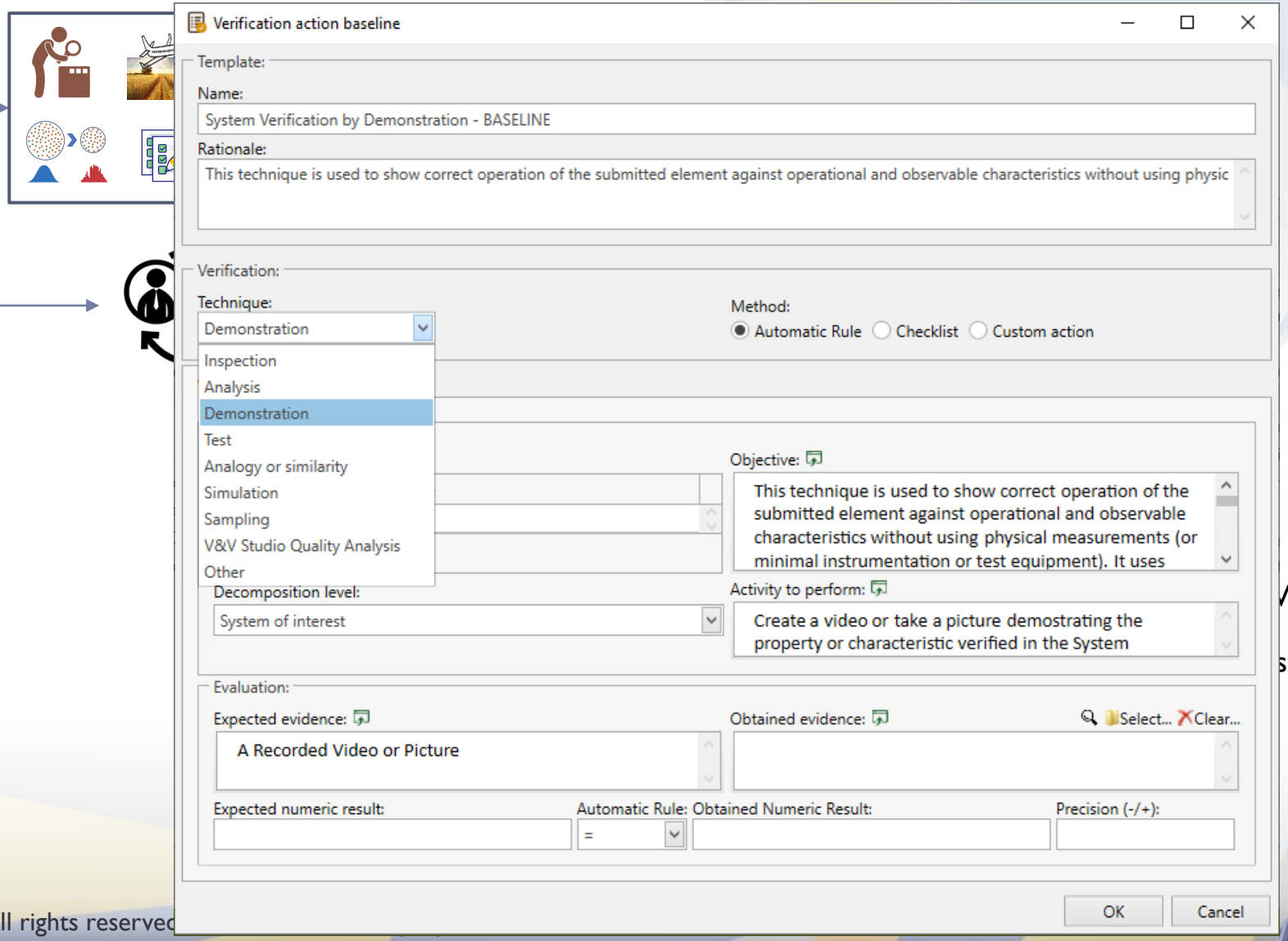

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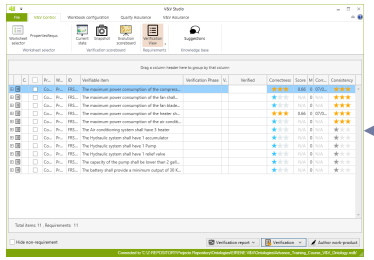
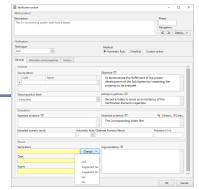
Perform Verification

Connect to the Source to collect the verifiable items





Execute the Verification Action for each Verifiable Item. If possible, the computer gathers the Information automatically

Computer applies the OK / KO decision process based on the standard guidelines.

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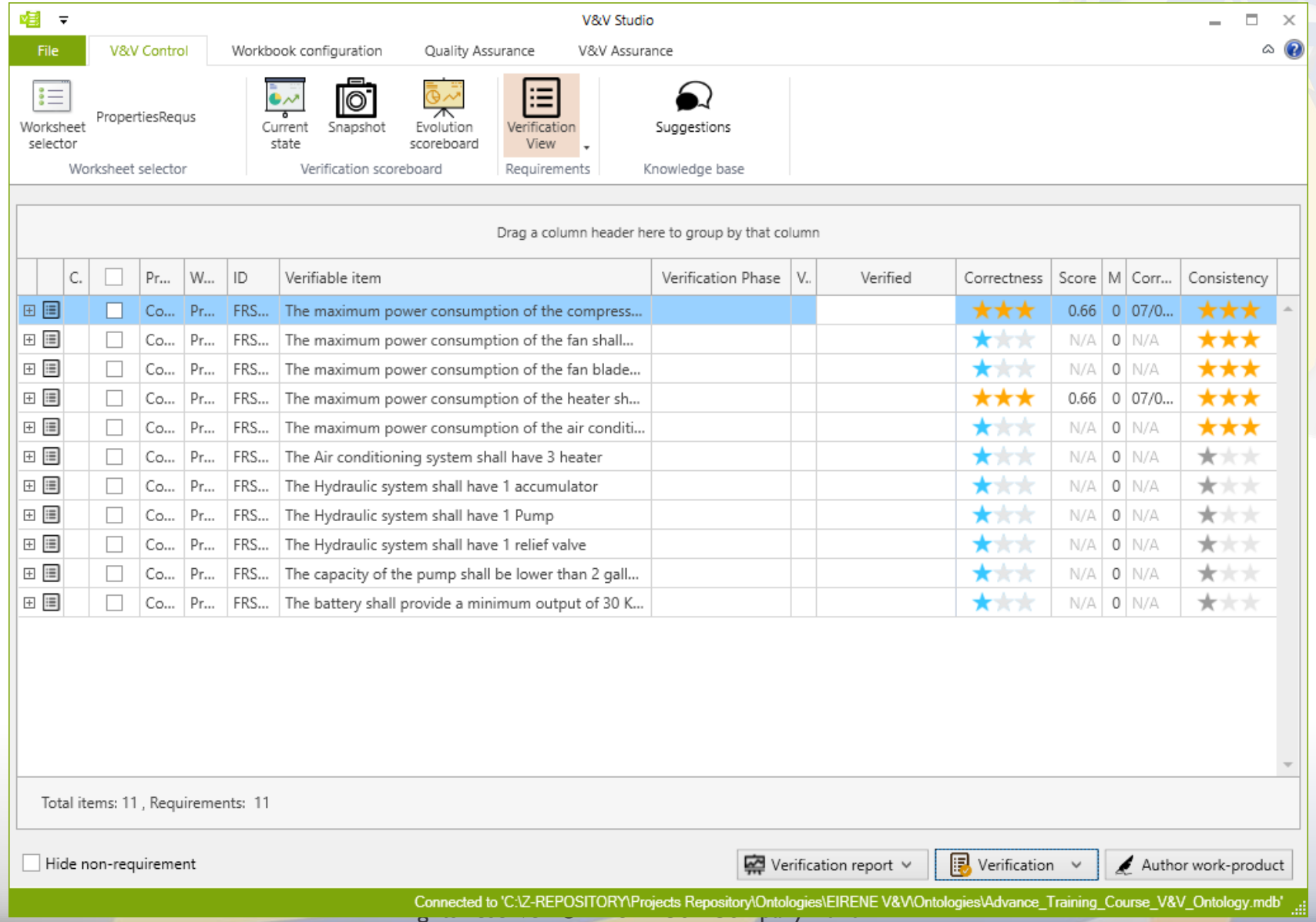
Connect to the Source to collect the verifiable items



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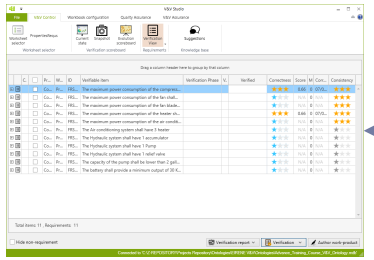
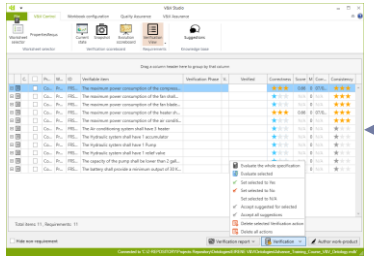
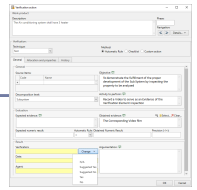


Ask the computer to calculate the verification process (if automatic)





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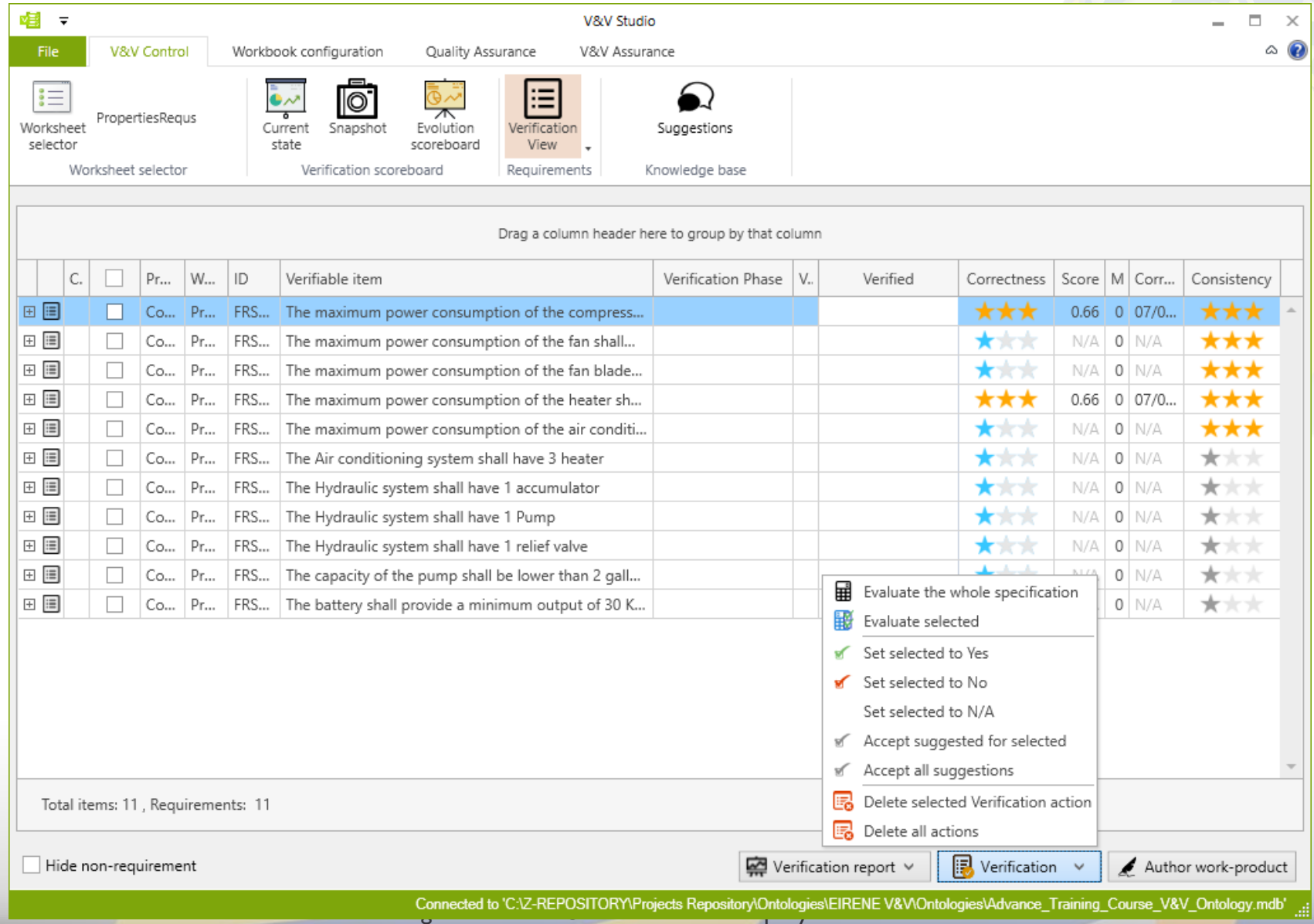
Verification Process in a Nutshell using V&V Studio

Connect to the Source to collect the verifiable items

Ask the computer to calculate the verification process (if automatic)



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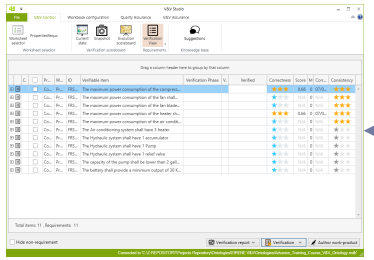

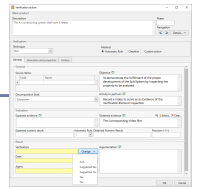

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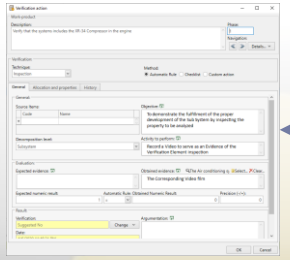

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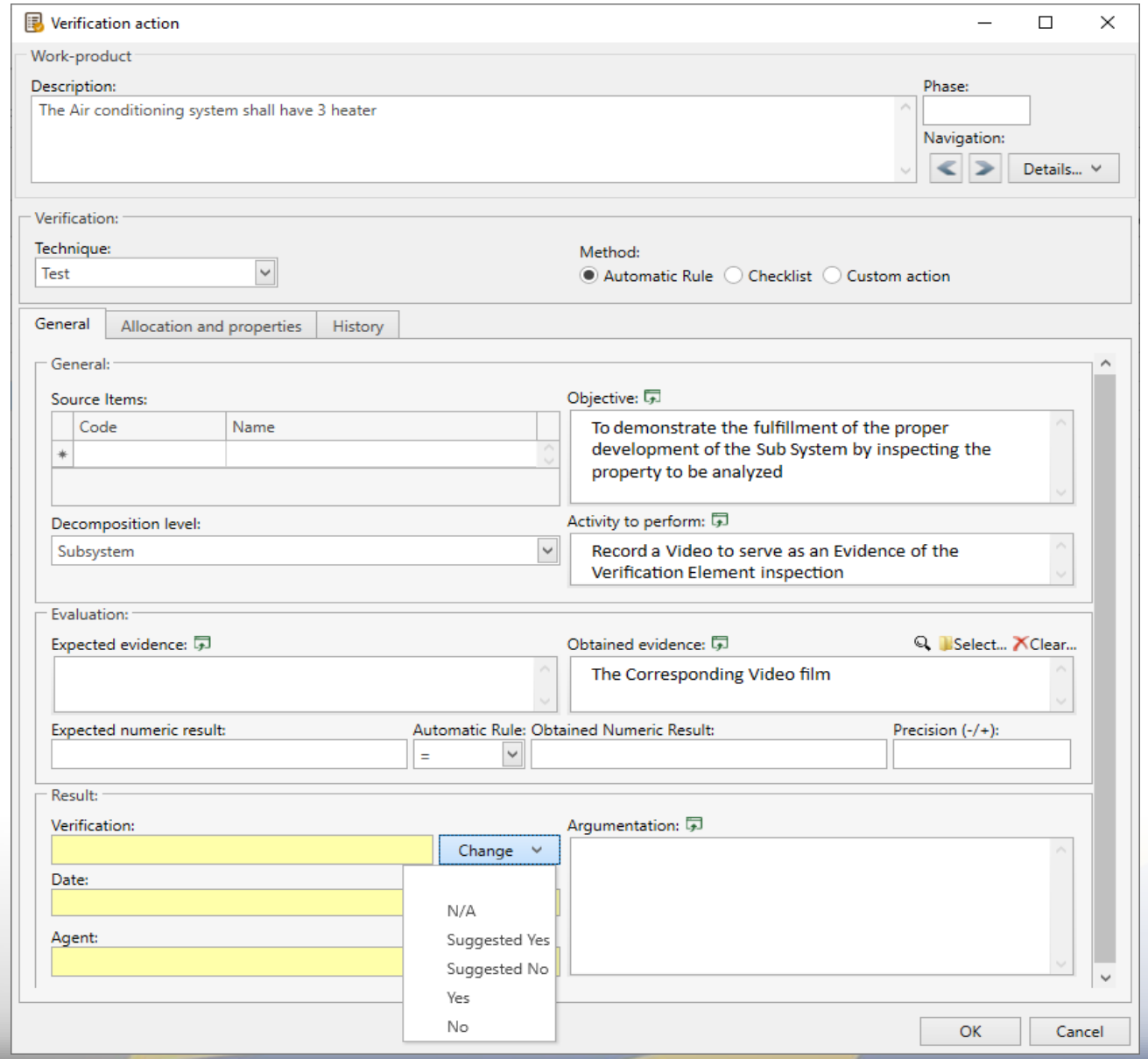

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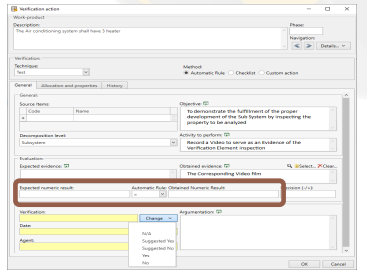

Computer automatically compares expected results with obtained results

- Suggested Yes
- Suggested No
- NA

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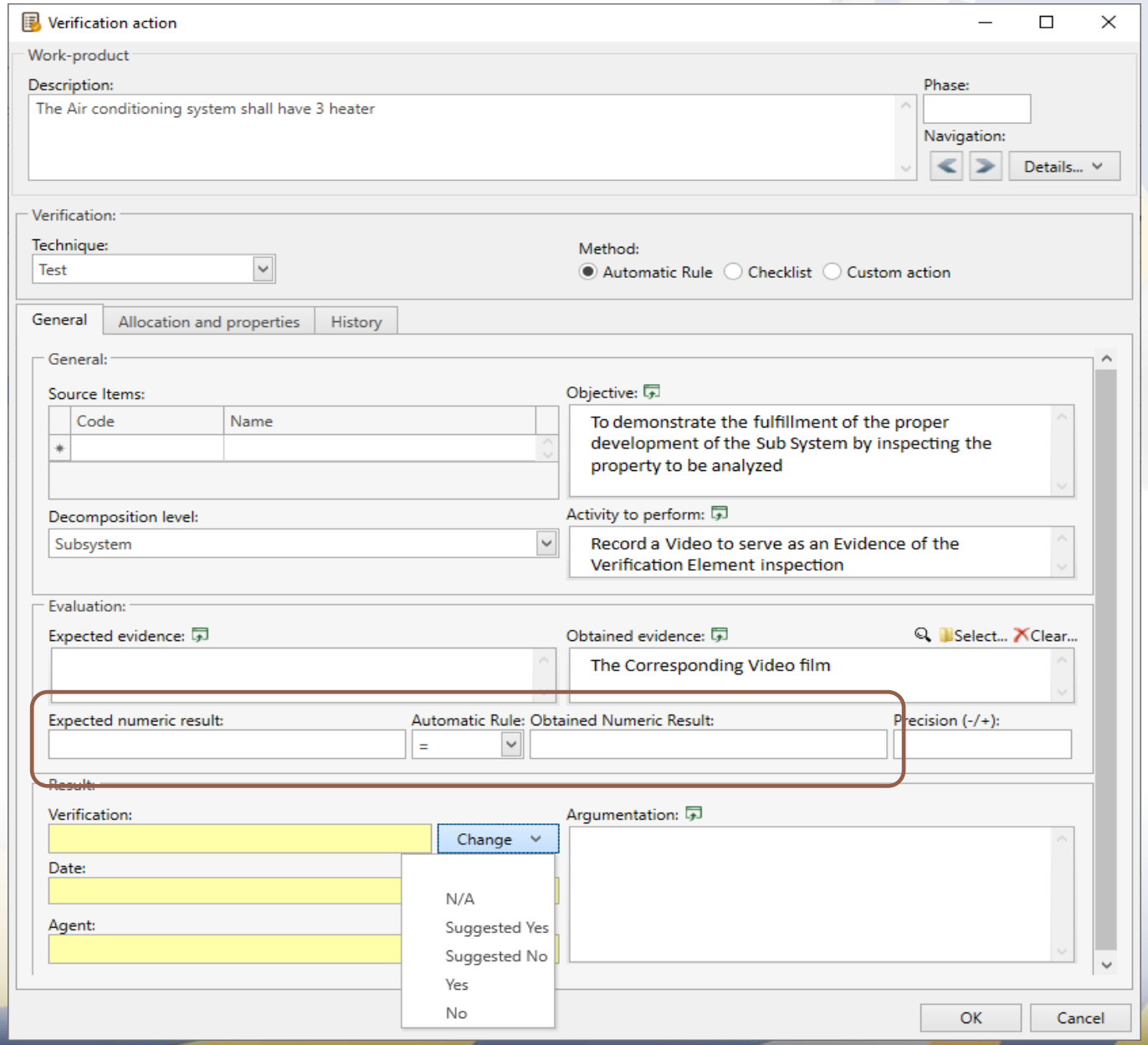

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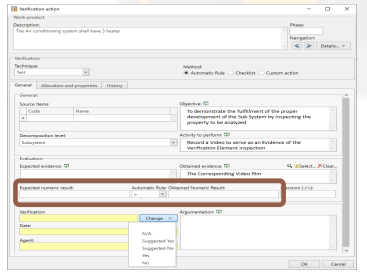
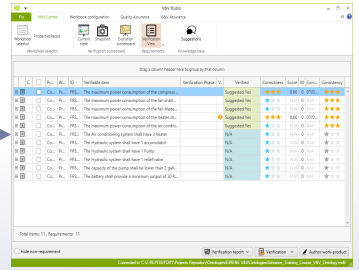


Computer automatically compares expected results with obtained results

- Suggested Yes
- Suggested No
- NA



Full vision and management of the results is presented

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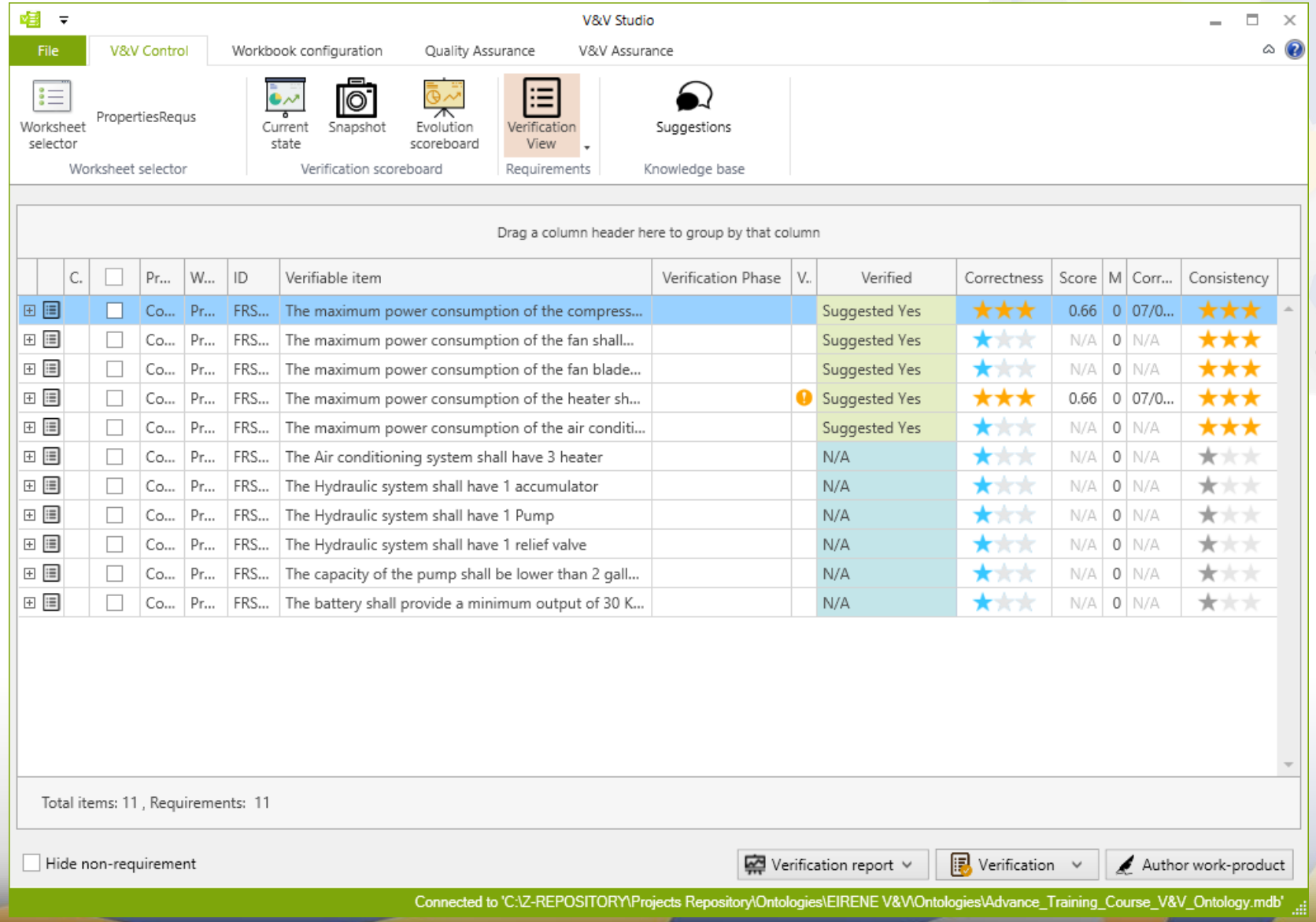
Verification Process in a Nutshell using V&V Studio

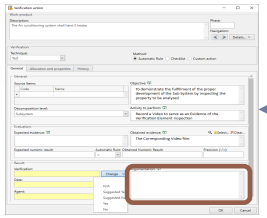


Computer automatically compares expected results with obtained results

- Suggested Yes
- Suggested No
- NA

Full vision and management of the results is presented

The VA supports the reporting of anomalies



Manage Results of Verification

Manage and record discovered anomalies and evidences

Track the Verification Process and manage Configuration

Build and maintain the RTVM

Provide proper reports

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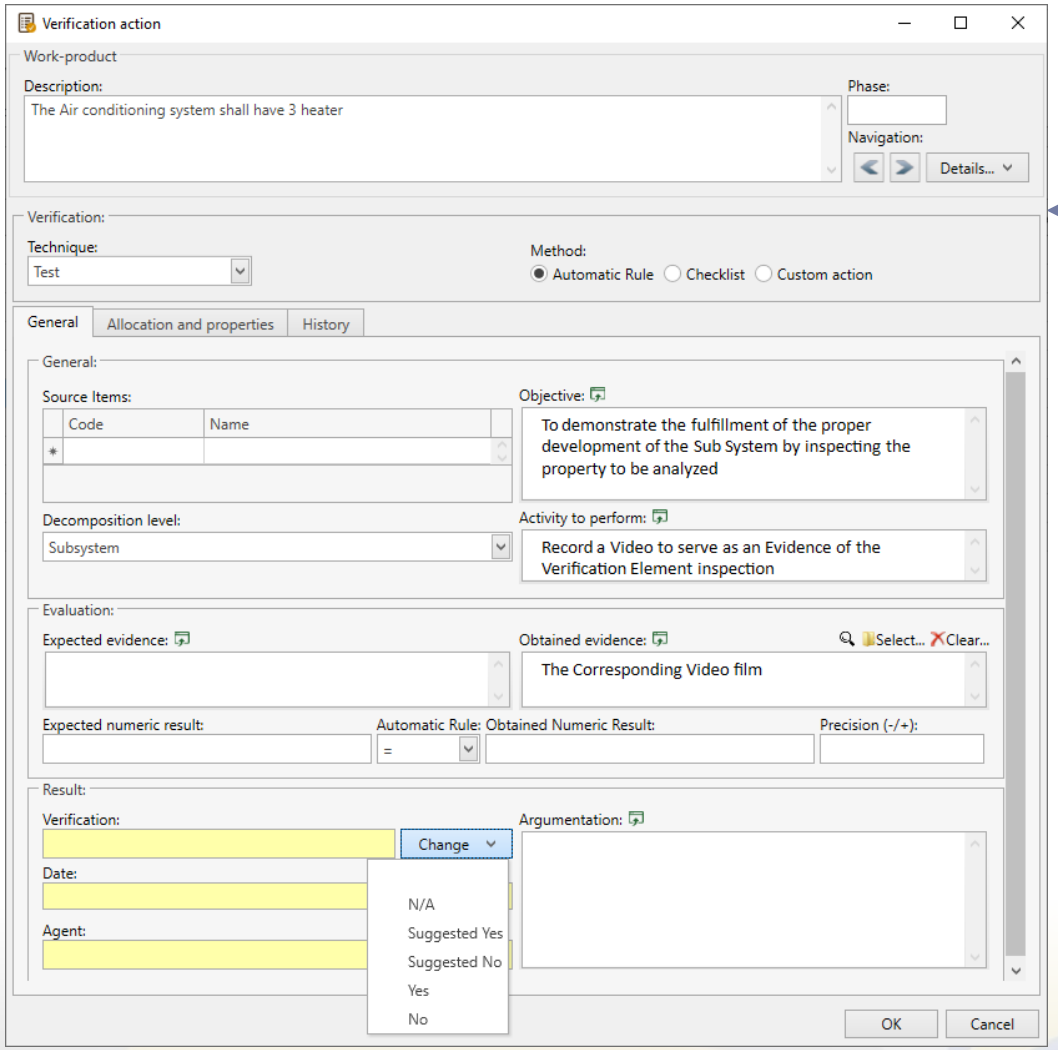

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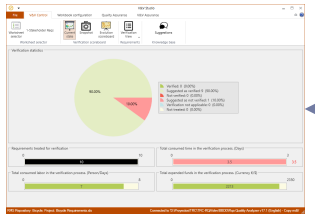
Manage Results of Verification

Manage and record discovered anomalies and evidences

Manage Verification Snapshots or Verification evolution along time



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Build and maintain the RTVM

Provide proper reports

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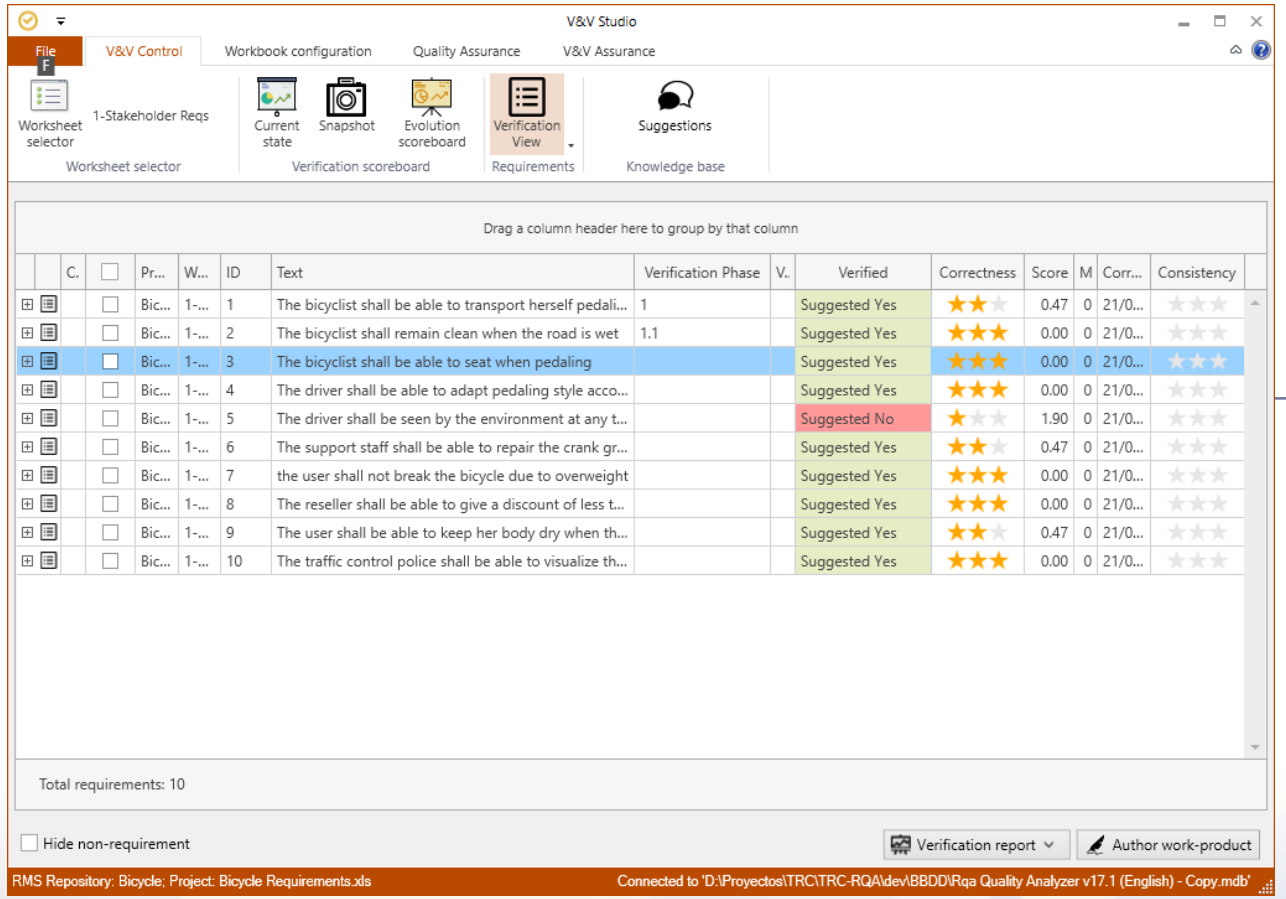

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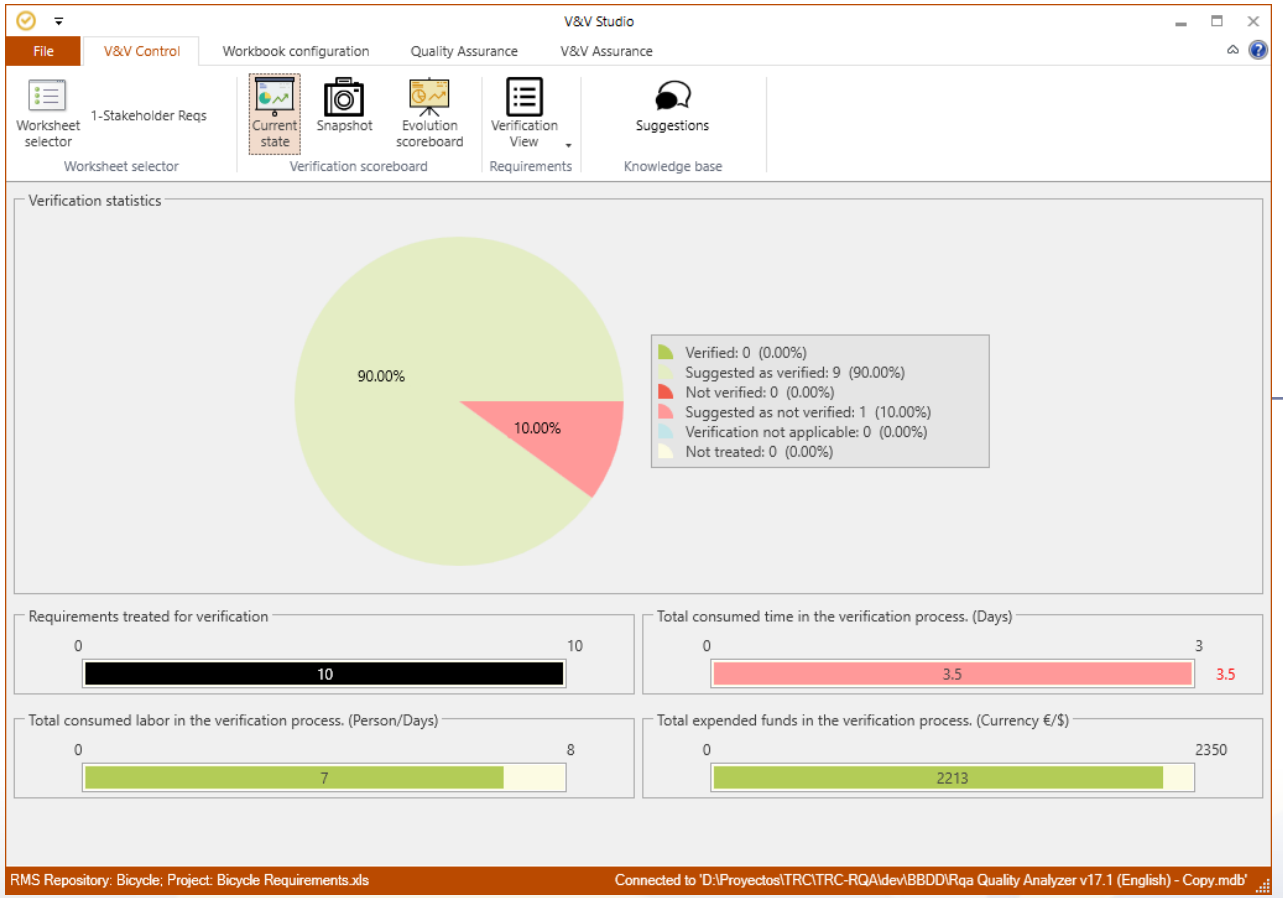

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Provide proper reports

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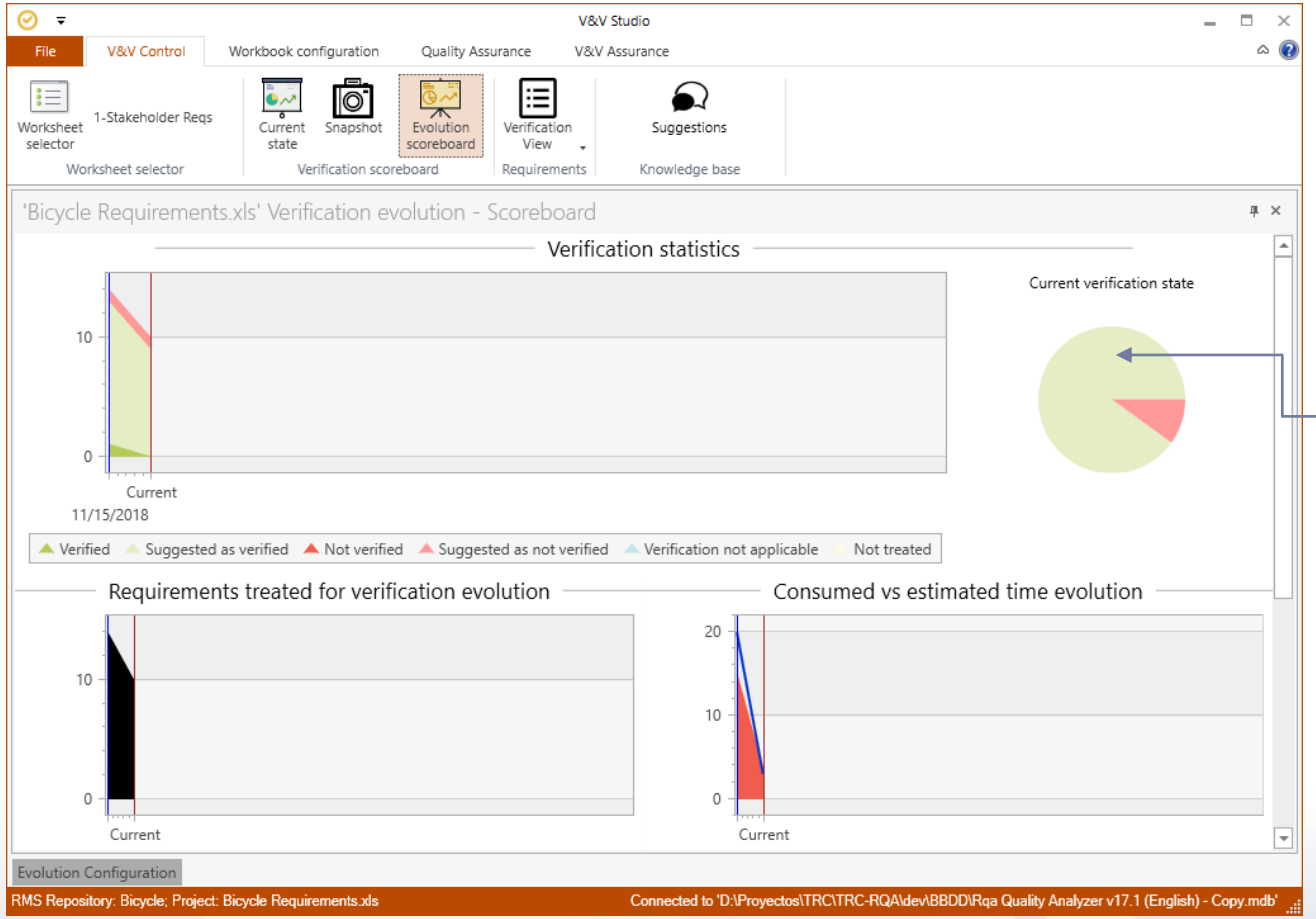

Manage Results of Verification

Manage and record discovered anomalies and evidences

Track the Verification Process and manage Configuration

Build and maintain the RTVM

Provide proper reports

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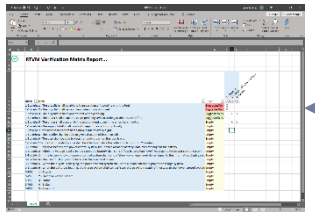
A RTVM is created linking Verifiable Items and Source Items



Build and maintain the RTVM

Provide proper reports

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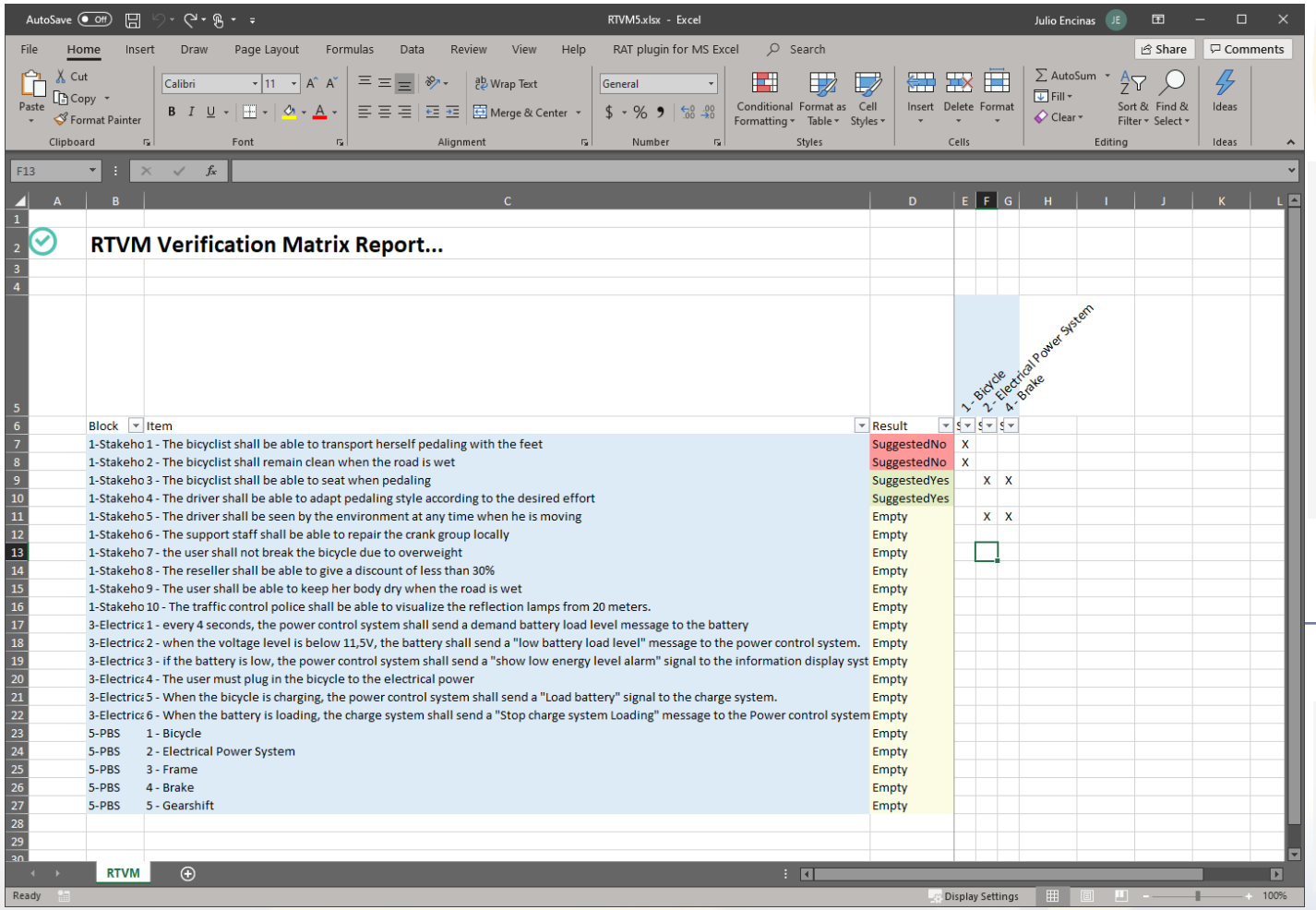

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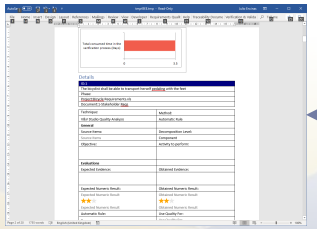
All reports can be produced in MS Word



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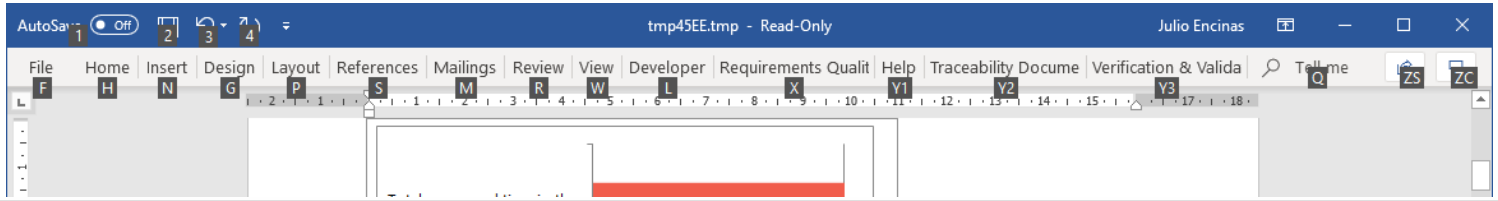
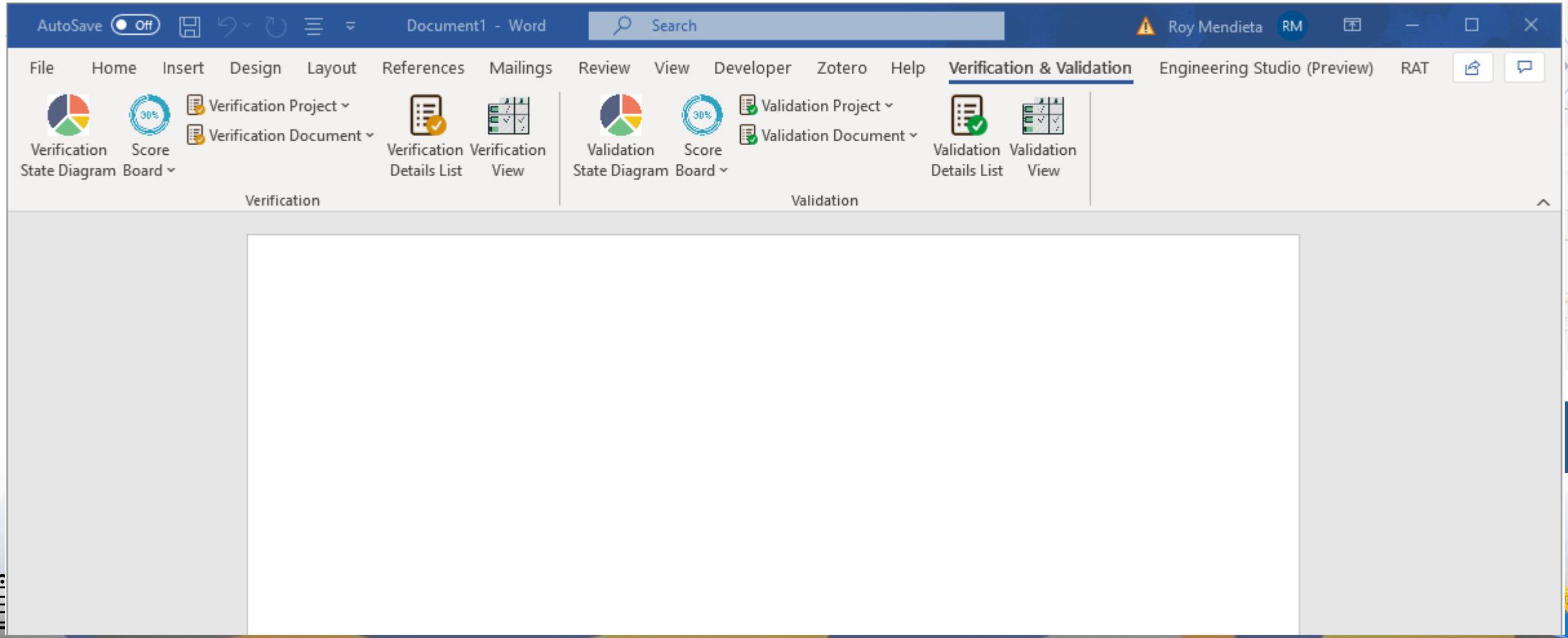
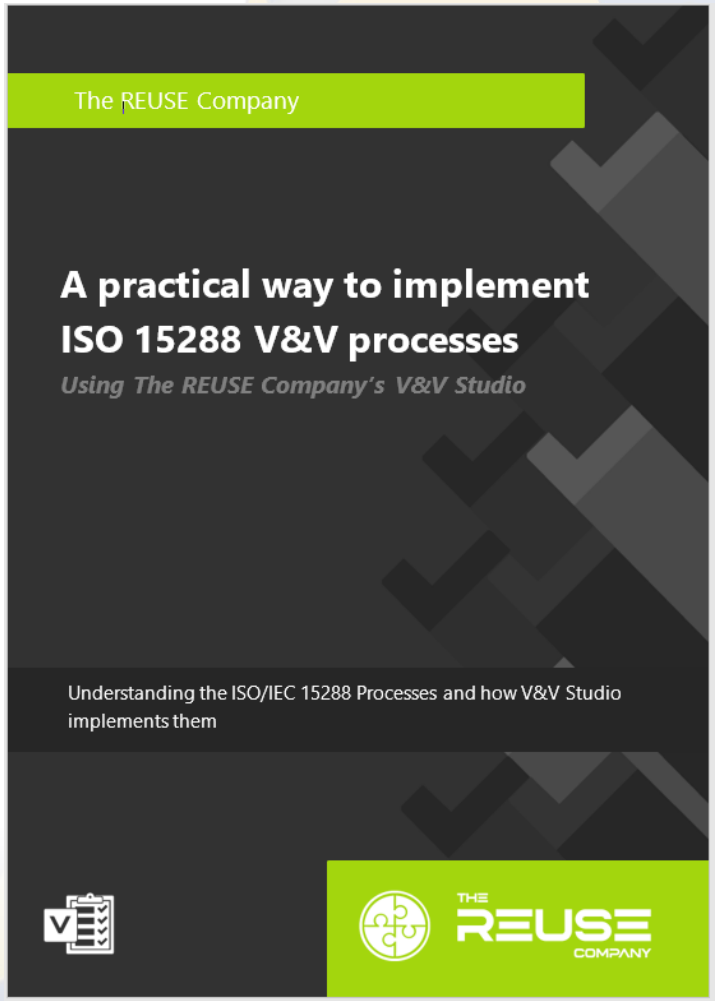
Manage Results of Verification





- Feel free to ask for the philosophy book
  - *"A practical way to implement ISO 15288 V&V processes, Using the REUSE Company's V&V Studio"*
- Only delivered on demand
- Get use of a specific OFFER CODE for Piloting the V&V Studio
  - POCSAH14



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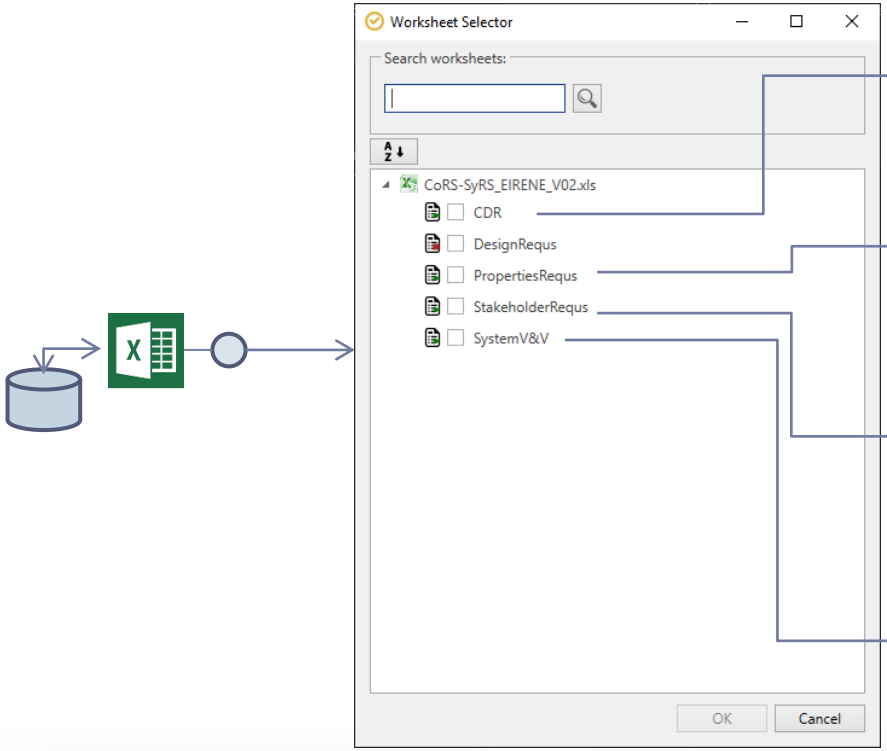

Critical Design Review Verification → Using a Check List from CMMI guidelines and Raytheon Systems Engineering practice

Property Requirements → Using a Consistency Quality Analysis Metric model

Stakeholder Requirements → Using a Correctness Quality Analysis Metric model

Verification of the System → Using a simulation model by running a FMU

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- **Writing Perfect Textual Requirements in Capella MBSE Tool: RAT – Authoring Tools providing real-time CCC Assessment and Consistency with the Underlying Model**

- This webinar presents an add-on to Capella that follows all the principles and features of the RAT - Authoring Tools on top of Requirements Modelling Tools (RMS), but now on top of a Modelling tool like Capella; thus enhancing a seamless consistency between textual requirements and models (model requirements).
- The webinar will include a demo of this new add-on, showing the following features:
  - Assisted authoring of requirements through pattern-based auto-completion
  - Real-time quality assessment
  - Maintenance of relations between textual and model-based requirements, and capitalization of links for change tracking
  - Synchronization of textual requirements: a round-trip approach between Capella and other external Requirements Management Systems

Dates:

- Jun 16 and 18, 2020

Capella

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Q&A

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